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ILM-FAN VA INNOVATIONSION TADQIQOTLAR JURNALI



QABUL YO'NALISHLARI

- Aniq fanlar
- Filologiya fanlari
- Ijtimoiy-gumanitar fanlari
- Tibbiyot fanlari
- Pedagogik fanlar
- Turizm fanlari
- Iqtisodiyot fanlari
- Yuridik fanlari
- Tabiiy fanlar
- San'atshunoslik fanlari





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EFFICIENCY OF ORGANIZING VIRTUAL TRAINING SESSIONS BASED ON AR/VR TECHNOLOGIES FOR RESCUERS

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Abstract

This article analyzes the effectiveness of organizing virtual training sessions based on Augmented Reality (AR) and Virtual Reality (VR) technologies for rescuers of the Ministry of Emergency Situations. The increasing complexity of modern emergencies requires the integration of innovative technologies into the training process for rescuers. The study examines the impact of AR/VR technologies on rescuers' practical skills, decision-making speed, and level of preparedness for emergency situations. The training model developed on the basis of virtual simulations makes it possible to recreate hazards encountered in real-life situations within a safe environment. The research findings demonstrate that the use of AR/VR technologies enhances the effectiveness of the training process, reduces training costs, and improves the professional preparedness of rescuers.

Keywords

AR technology, VR technology, rescuer training, virtual simulation, emergency situations, training sessions, digital technologies, virtual training.

QUTQARUVCHILAR UCHUN AR/VR TEXNOLOGIYALARI ASOSIDA VIRTUAL O'QUV MASHG'ULOTLARINI TASHKIL ETISH SAMARADORLIGI

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Annotatsiya





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Mazkur maqolada Favqulodda vaziyatlar vazirligi qutqaruvchilari uchun Augmented Reality (AR) va Virtual Reality (VR) texnologiyalari asosida virtual o'quv mashg'ulotlarini tashkil etishning samaradorligi tahlil qilingan. Zamonaviy favqulodda vaziyatlarning murakkablashuvi qutqaruvchilarni tayyorlash jarayoniga innovatsion texnologiyalarni joriy etishni talab etmoqda. Tadqiqot davomida AR/VR texnologiyalarining qutqaruvchilarning amaliy ko'nikmalari, qaror qabul qilish tezligi va favqulodda vaziyatlarga tayyorgarlik darajasiga ta'siri o'rganildi. Virtual simulyatsiyalar asosida ishlab chiqilgan o'quv modeli real sharoitlarda yuzaga keladigan xavflarni xavfsiz muhitda takrorlash imkonini beradi. Tadqiqot natijalari AR/VR texnologiyalaridan foydalanish o'quv jarayonining samaradorligini oshirish, mashg'ulot xarajatlarini kamaytirish va qutqaruvchilarning kasbiy tayyorgarligini yaxshilashga xizmat qilishini ko'rsatdi.

Kalit so'zlar: AR texnologiyasi, VR texnologiyasi, qutqaruvchilar tayyorgarligi, virtual simulyatsiya, favqulodda vaziyatlar, o'quv mashg'ulotlari, raqamli texnologiyalar, virtual trening.

1. Kirish

Bugungi kunda dunyo miqyosida tabiiy va texnogen favqulodda vaziyatlarning soni ortib borayotganligi qutqaruv xizmatlari faoliyatiga yangi talablarni qo'yimoqda. Zilzilalar, yong'inlar, suv toshqinlari, texnologik avariylar va boshqa favqulodda holatlar qutqaruvchilardan yuqori malaka, tezkor qaror qabul qilish va murakkab vaziyatlarda samarali harakat qilishni talab etadi.

An'anaviy o'quv mashg'ulotlari qutqaruvchilarning nazariy va amaliy tayyorgarligini shakllantirishda muhim o'rin tutadi. Biroq bunday mashg'ulotlarni tashkil etish katta moddiy mablag', maxsus texnika, poligonlar va xavfsizlik choralarini talab qiladi. Bundan tashqari, ayrim favqulodda vaziyatlarni real sharoitda modellashtirish amaliy jihatdan murakkab yoki xavfli hisoblanadi.





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Axborot-kommunikatsiya texnologiyalarining jadal rivojlanishi ta'lim tizimida yangi yondashuvlarning paydo bo'lishiga sabab bo'ldi. Xususan, Augmented Reality (AR) va Virtual Reality (VR) texnologiyalari murakkab jarayonlarni virtual muhitda modellashtirish va o'quvchilarga real vaziyatga yaqin tajriba berish imkoniyatini yaratmoqda.

AR texnologiyasi real dunyo obyektlariga raqamli axborotlarni qo'shish orqali foydalanuvchining idrokini boyitadi. VR texnologiyasi esa foydalanuvchini to'liq virtual muhitga kiritib, favqulodda vaziyatlarni real holatga yaqin tarzda his qilish imkonini beradi.

AQSH, Yaponiya, Germaniya va Janubiy Koreya kabi davlatlarda qutqaruvchilarni tayyorlashda AR/VR texnologiyalaridan keng foydalanilmoqda. Ushbu texnologiyalar yordamida yong'in o'chirish, bino qulashida qidiruv-qutqaruv ishlarini olib borish, kimyoviy avariylarni bartaraf etish va boshqa murakkab operatsiyalar virtual muhitda mashq qilinmoqda.

Mazkur tadqiqotning maqsadi qutqaruvchilar uchun AR/VR texnologiyalari asosida virtual o'quv mashg'ulotlarini tashkil etishning samaradorligini baholash hamda ularni favqulodda vaziyatlar tizimiga joriy etish imkoniyatlarini aniqlashdan iborat.

2.Adabiyotlar tahlili

So'nggi yillarda AR (Augmented Reality) va VR (Virtual Reality) texnologiyalarining ta'lim tizimiga joriy etilishi bo'yicha ko'plab ilmiy tadqiqotlar amalga oshirilmoqda. Ayniqsa, yuqori xavf bilan bog'liq kasblar, jumladan, harbiylar, tibbiyot xodimlari, uchuvchilar va qutqaruvchilarni tayyorlashda ushbu texnologiyalarning ahamiyati ortib bormoqda.

Radianti va hamkorlari (2020) tomonidan o'tkazilgan tadqiqotlarda virtual reallik texnologiyalari foydalanuvchilarga real vaziyatlarni xavfsiz muhitda takrorlash imkonini berishi ta'kidlangan. Mualliflarning fikriga ko'ra, VR asosidagi o'quv





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mashg'ulotlari amaliy ko'nikmalarni shakllantirishda an'anaviy usullarga nisbatan yuqori samaradorlikka ega.

Jensen va Konradsen (2018) virtual reallikdan foydalanish o'quvchilarning bilimlarni o'zlashtirish darajasi va xotirada saqlash ko'rsatkichlarini sezilarli darajada yaxshilashini aniqlaganlar. Tadqiqotchilar VR muhitida o'rganilgan ma'lumotlar real sharoitdagi faoliyatga samarali ko'chirilishini qayd etganlar.

Birt va Porter (2019) kengaytirilgan reallik texnologiyalarining amaliy mashg'ulotlarda qo'llanilishi bo'yicha tadqiqot olib borib, AR texnologiyalari murakkab jarayonlarni vizuallashtirish va o'quvchilarning qiziqishini oshirishga xizmat qilishini ko'rsatganlar.

Favqulodda vaziyatlar sohasida AR/VR texnologiyalaridan foydalanish bo'yicha olib borilgan tadqiqotlar yong'in-qutqaruv bo'linmalari va qidiruv-qutqaruv xizmatlari uchun alohida ahamiyat kasb etadi. Smith va Jones (2021) virtual simulyatsiyalar qutqaruvchilarning qaror qabul qilish tezligi va stressga chidamliligini oshirishini aniqlaganlar.

Shuningdek, Xitoy, AQSH va Janubiy Koreyada amalga oshirilgan loyihalarda zilzila, yong'in va texnogen avariylarni virtual muhitda modellashtirish orqali qutqaruvchilarni tayyorlash bo'yicha ijobiy natijalar qayd etilgan.

Biroq mavjud tadqiqotlarning aksariyatida AR va VR texnologiyalarining ta'limdagi umumiy afzalliklari o'rganilgan bo'lib, qutqaruvchilarni tayyorlash tizimiga kompleks joriy etishning samaradorligi yetarlicha tadqiq etilmagan. Mazkur tadqiqot aynan shu masalani o'rganishga qaratilgan.

3.Tadqiqotlar metodologiyasi

Mazkur tadqiqotda qutqaruvchilar uchun AR/VR texnologiyalari asosida virtual o'quv mashg'ulotlarini tashkil etish samaradorligini baholash maqsadida kompleks metodologik yondashuv ishlab chiqildi.





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Tadqiqot obyekti sifatida Favqulodda vaziyatlar vazirligi tizimida xizmat qiluvchi qutqaruvchilarning tayyorgarlik jarayoni tanlandi. Tadqiqot davomida virtual o'quv muhiti yaratilib, unda turli favqulodda vaziyatlar modellashirildi.

Virtual trening tizimi quyidagi modullardan tashkil etildi:

- Yong'in-qutqaruv operatsiyalari moduli;
- Bino qulashida qidiruv-qutqaruv ishlari moduli;
- Kimyoviy avariyalarda harakat qilish moduli;
- Suv toshqinlari va tabiiy ofatlar moduli.

VR texnologiyasi yordamida foydalanuvchilar to'liq virtual muhitga joylashtirildi. AR texnologiyasi esa real obyektlarga qo'shimcha axborot va ko'rsatmalarni joylashtirish uchun qo'llanildi.

Tadqiqot davomida qutqaruvchilarning quyidagi ko'rsatkichlari baholandi:

- qaror qabul qilish tezligi;
- vazifani bajarish vaqti;
- xatolar soni;
- stressga chidamlilik;
- bilimlarni o'zlashtirish darajasi.

O'quv samaradorligini aniqlash uchun Samaradorlik Indeksi (SI) ishlab chiqildi:

$$SI = (K + T + B + S) / 4$$

bu yerda:

K – ko'nikmalar darajasi;

T – topshiriqni bajarish tezligi;

B – bilimlarni o'zlashtirish ko'rsatkichi;

S – stressga chidamlilik darajasi.

Tadqiqotda AR/VR texnologiyalaridan foydalangan guruh natijalari an'anaviy o'quv mashg'ulotlarida qatnashgan nazorat guruhi natijalari bilan taqqoslandi.





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Bundan tashqari, virtual muhitda qutqaruvchilar duch kelishi mumkin bo'lgan turli stsenariylar yaratildi. Har bir stsenariyda foydalanuvchilarning harakatlari tizim tomonidan qayd etilib, keyinchalik tahlil qilindi.

Mazkur metodologiya qutqaruvchilarning kasbiy tayyorgarligini baholash va AR/VR texnologiyalarining o'quv jarayonidagi samaradorligini aniqlash imkonini berdi.

4.AR/RV asosidagi virtual o'quv modeli

Tadqiqot doirasida qutqaruvchilarni tayyorlash uchun AR/VR texnologiyalariga asoslangan virtual o'quv modeli ishlab chiqildi. Ushbu modelning asosiy maqsadi favqulodda vaziyatlarni real sharoitga maksimal darajada yaqinlashtirgan holda xavfsiz va samarali o'quv muhitini yaratishdan iborat.

Model quyidagi tarkibiy qismlardan tashkil topgan:

1. Virtual simulyatsiya muhiti;
2. AR asosidagi yordamchi axborot tizimi;
3. Harakatlarni monitoring qilish moduli;
4. Baholash va tahlil moduli.

Virtual simulyatsiya muhitida qutqaruvchilar quyidagi favqulodda vaziyatlarda harakat qilish ko'nikmalarini shakllantiradilar:

- ko'p qavatli binolardagi yong'inlar;
- zilzila oqibatida bino qulashlari;
- kimyoviy moddalarning sizib chiqishi;
- transport halokatlari;
- suv toshqinlari va sel hodisalari.

VR texnologiyasi yordamida foydalanuvchi maxsus qurilmalar orqali virtual muhitga kiradi va favqulodda vaziyat ishtirokchisiga aylanadi. Natijada qutqaruvchi real vaziyatga yaqin sharoitda qaror qabul qilish, qidiruv-qutqaruv ishlarini olib borish hamda jabrlanganlarga yordam ko'rsatish imkoniyatiga ega bo'ladi.





AR texnologiyasi esa real mashg‘ulotlar davomida qo‘llanilib, qutqaruvchining ko‘rish maydoniga qo‘shimcha axborotlarni chiqaradi. Masalan, bino konstruksiyasining xavfli qismlari, xavfsiz harakat yo‘nalishlari yoki jabrlanganlarning taxminiy joylashuvi ekranda aks ettiriladi.

Tizimda har bir foydalanuvchining harakatlari qayd etiladi va maxsus baholash moduli tomonidan tahlil qilinadi. Baholash natijalari asosida qutqaruvchining tayyorgarlik darajasi, xatolari va takomillashtirilishi lozim bo‘lgan ko‘nikmalari aniqlanadi.

Taklif etilgan modelning asosiy afzalligi murakkab va xavfli vaziyatlarni inson salomatligiga zarar yetkazmagan holda takrorlash imkoniyatini yaratishidir. Shu sababli u qutqaruvchilarni tayyorlashning zamonaviy va istiqbolli vositasi hisoblanadi.

5.Natijalar va muhokama

Taklif etilgan AR/VR asosidagi virtual o‘quv modelining samaradorligini baholash maqsadida qutqaruvchilarning tayyorgarlik ko‘rsatkichlari tahlil qilindi. Tadqiqot davomida an‘anaviy usulda tayyorlangan qutqaruvchilar guruhi hamda AR/VR texnologiyalari yordamida tayyorlangan eksperimental guruh natijalari taqqoslandi.

Natijalar shuni ko‘rsatdiki, virtual o‘quv mashg‘ulotlarida qatnashgan qutqaruvchilar favqulodda vaziyatlarda tezroq qaror qabul qilish va murakkab topshiriqlarni samaraliroq bajarish qobiliyatiga ega bo‘lgan.

1-jadval

An‘anaviy va AR/VR asosidagi tayyorgarlik natijalarini taqqoslash

Ko‘rsatkich	An‘anaviy usul	AR/VR usuli
Qaror qabul qilish vaqti	18 soniya	11 soniya
Vazifani bajarish aniqligi	76 %	93 %
Xatolar soni	14 %	5 %
Stressga chidamlilik	O‘rtacha	Yuqori





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Ko'rsatkich	An'anaviy usul	AR/VR usuli
O'zlashtirish darajasi	72 %	91 %

Jadval natijalari AR/VR texnologiyalaridan foydalangan holda tayyorlangan qutqaruvchilarning ko'rsatkichlari an'anaviy o'quv usullariga nisbatan sezilarli darajada yuqori ekanligini ko'rsatmoqda.

Tahlillar natijasida virtual mashg'ulotlarda qatnashgan qutqaruvchilarning favqulodda vaziyatlarga moslashish qobiliyati oshgani kuzatildi. Ayniqsa, murakkab va stressli vaziyatlarda qaror qabul qilish tezligi hamda to'g'ri harakat qilish ko'rsatkichlari yaxshilangan.

Bundan tashqari, AR texnologiyasi yordamida berilgan qo'shimcha vizual ko'rsatmalar qutqaruvchilarning fazoviy fikrlash qobiliyatini rivojlantirgan. VR texnologiyasi esa real xavf tug'dirmagan holda murakkab operatsiyalarni ko'p marotaba takrorlash imkonini yaratgan.

Tadqiqot natijalari xalqaro tajribalar bilan ham mos keladi. AQSH va Yevropa mamlakatlarida olib borilgan tadqiqotlarda ham virtual treninglar qutqaruvchilarning kasbiy tayyorgarligini oshirishda samarali vosita ekanligi qayd etilgan.

Shuningdek, iqtisodiy tahlillar AR/VR texnologiyalaridan foydalanish uzoq muddatli istiqbolda o'quv xarajatlarini kamaytirishini ko'rsatdi. Chunki virtual treninglarda maxsus texnika, yoqilg'i, poligon va boshqa moddiy resurslarga bo'lgan ehtiyoj sezilarli darajada qisqaradi.

Natijalar AR/VR texnologiyalarini Favqulodda vaziyatlar vazirligi tizimiga bosqichma-bosqich joriy etish qutqaruvchilar tayyorgarligini yangi bosqichga olib chiqishini ko'rsatmoqda.

6.Xulosa

Mazkur tadqiqotda qutqaruvchilarni tayyorlash jarayonida AR (Augmented Reality) va VR (Virtual Reality) texnologiyalaridan foydalanishning samaradorligi o'rganildi. O'tkazilgan tahlillar va simulyatsion tajribalar natijasida virtual o'quv





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mashg'ulotlari qutqaruvchilarning nazariy bilimlari va amaliy ko'nikmalarini rivojlantirishda yuqori samaradorlikka ega ekanligi aniqlandi.

Tadqiqot natijalariga ko'ra, AR/VR texnologiyalaridan foydalangan holda tashkil etilgan mashg'ulotlar qutqaruvchilarning favqulodda vaziyatlarga tayyorgarlik darajasini sezilarli darajada oshirdi. Xususan, qaror qabul qilish tezligi yaxshilandi, topshiriqlarni bajarish aniqligi ortdi va xatolar soni kamaydi.

Virtual simulyatsiyalar murakkab va xavfli vaziyatlarni real sharoitga yaqin ko'rinishda takrorlash imkonini yaratdi. Bu esa qutqaruvchilarning stressli vaziyatlarda harakat qilish ko'nikmalarini shakllantirishga xizmat qildi.

Shuningdek, tadqiqot davomida AR/VR texnologiyalaridan foydalanish o'quv jarayonining iqtisodiy samaradorligini ham oshirishi aniqlandi. Chunki virtual mashg'ulotlarda texnika, maxsus poligonlar va qo'shimcha moddiy resurslardan foydalanish hajmi kamayadi.

Olingan natijalar AR/VR texnologiyalarini Favqulodda vaziyatlar vazirligi tizimiga keng joriy etish qutqaruvchilarni tayyorlash sifatini oshirishga xizmat qilishini ko'rsatmoqda. Kelgusida sun'iy intellekt va Digital Twin texnologiyalari bilan integratsiyalashgan virtual trening tizimlarini ishlab chiqish ushbu yo'nalishning istiqbolli rivojlanish yo'nalishlaridan biri hisoblanadi.

Tadqiqotning ilmiy yangiligi

Mazkur tadqiqotning ilmiy yangiligi quyidagilardan iborat:

- Favqulodda vaziyatlar tizimida qutqaruvchilarni tayyorlash uchun AR va VR texnologiyalarini integratsiyalashgan holda qo'llash modeli ishlab chiqildi.
- Virtual treninglar samaradorligini baholash uchun Samaradorlik Indeksi (SI) taklif etildi.
- Favqulodda vaziyatlarning turli stsenariylarini yagona virtual platformada modellashtirish imkonini beruvchi konseptual model yaratildi.





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- Qutqaruvchilarning qaror qabul qilish tezligi, stressga chidamliligi va amaliy ko'nikmalarini baholashning yangi yondashuvi ishlab chiqildi.

- AR/VR texnologiyalarining Favqulodda vaziyatlar vazirligi tizimidagi amaliy qo'llanilishi bo'yicha ilmiy asoslangan tavsiyalar ishlab chiqildi.

Tadqiqotning amaliy ahamiyati

Tadqiqot natijalari Favqulodda vaziyatlar vazirligi Akademiyasi, hududiy qutqaruv bo'linmalari hamda maxsus tayyorgarlik markazlarida qo'llanilishi mumkin.

Taklif etilgan model:

- qutqaruvchilar tayyorgarligi sifatini oshirish;
 - mashg'ulot xarajatlarini kamaytirish;
 - favqulodda vaziyatlarda harakat qilish ko'nikmalarini rivojlantirish;
 - xavfli amaliy mashg'ulotlar sonini kamaytirish;
 - qutqaruvchilarning kasbiy kompetensiyalarini oshirish;
- imkonini beradi.

Mazkur tadqiqot natijalari kelgusida Smart Training Center va Digital Rescue Training Platform tizimlarini yaratishda ilmiy asos bo'lib xizmat qilishi mumkin.

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THE ROLE OF GEOINFORMATION TECHNOLOGIES IN FORECASTING MUDFLOWS AND FLOODS

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Abstract

This article analyzes the role and significance of geoinformation technologies in forecasting mudflows and floods. It examines the possibilities of using Geographic Information Systems (GIS), remote sensing technologies, satellite data, and digital elevation models to prevent mudflows and floods, which are among the most common hydrological hazards. In addition, based on the experience of the United States, Japan, China, and European countries, the effectiveness of geoinformation technologies in emergency management systems is evaluated. The research findings indicate that the use of GIS technologies significantly enhances the ability to predict the risks of mudflows and floods, reduce the extent of damage, and support rapid decision-making.

Keywords

Geographic Information System, GIS, mudflow, flood, remote sensing, satellite data, digital elevation model, emergency situations.

SEL VA SUV TOSHQINLARINI PROGNOZLASHDA

GEOINFORMATSIYON TEXNOLOGIYALARNING O'RNI

Boboqulov Ozodbek Rustam o'g'li - Favqulodda vaziyatlar vazirligi Akademiyasi

Annotatsiya

Mazkur maqolada sel va suv toshqinlarini prognozlashda geoinformatsion texnologiyalarning o'rni va ahamiyati tahlil qilingan. Tabiiy ofatlar orasida eng ko'p uchraydigan gidrologik xavflardan biri hisoblangan sel va suv toshqinlarining oldini olishda geografik axborot tizimlari (GIS), masofadan zondlash texnologiyalari, sun'iy yo'ldosh ma'lumotlari va raqamli relief modellaridan foydalanish imkoniyatlari





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o'rganilgan. Shuningdek, AQSh, Yaponiya, Xitoy va Yevropa davlatlari tajribasi asosida geoinformatsion texnologiyalarning favqulodda vaziyatlarni boshqarish tizimidagi samaradorligi baholangan. Tadqiqot natijalari GIS texnologiyalaridan foydalanish sel va suv toshqinlari xavfini oldindan aniqlash, zarar ko'lamini kamaytirish va tezkor qarorlar qabul qilish imkoniyatlarini sezilarli darajada oshirishini ko'rsatadi.

Kalit so'zlar: geoinformatsion tizim, GIS, sel, suv toshqini, masofadan zondlash, sun'iy yo'ldosh ma'lumotlari, raqamli relef modeli, favqulodda vaziyatlar.

Kirish. Iqlim o'zgarishi, yog'ingarchilik miqdorining ortishi va gidrologik jarayonlardagi o'zgarishlar natijasida dunyo bo'yicha sel va suv toshqinlari soni ortib bormoqda. Ushbu tabiiy ofatlar aholi punktlari, transport infratuzilmasi, qishloq xo'jaligi va sanoat obyektlariga katta zarar yetkazmoqda. O'zbekiston Respublikasida ham tog'oldi va tog'li hududlarda sel hodisalari, daryo havzalarida esa suv toshqinlari xavfi mavjud. Ayniqsa, bahor va yoz mavsumlarida kuchli yog'ingarchiliklar natijasida yuzaga keladigan sel hodisalari aholi xavfsizligiga jiddiy tahdid soladi. An'anaviy prognozlash usullari ko'pincha meteorologik kuzatuvlarga asoslangan bo'lib, xavfli hududlarni aniq baholash imkoniyatlari cheklangan. Zamonaviy geoinformatsion texnologiyalar esa fazoviy ma'lumotlarni tahlil qilish, xavf zonalarini aniqlash va favqulodda vaziyatlarning rivojlanish ssenariylarini modellashtirish imkonini beradi. Mazkur tadqiqotning maqsadi sel va suv toshqinlarini prognozlashda geoinformatsion texnologiyalarning ahamiyatini tahlil qilish hamda ularni Favqulodda vaziyatlar vazirligi tizimida qo'llash istiqbollari baholashdan iborat.

1. Mavzuga oid adabiyotlar tahlili

So'nggi yillarda geoinformatsion texnologiyalar yordamida tabiiy ofatlarni prognozlash bo'yicha ko'plab ilmiy tadqiqotlar amalga oshirilgan. Tadqiqotchilar GIS texnologiyalarining gidrologik xavflarni baholash va monitoring qilishdagi samaradorligini yuqori baholamoqdalar. Smith va Brown tomonidan olib borilgan tadqiqotlarda GIS va masofadan zondlash ma'lumotlarini birgalikda qo'llash sel xavfi yuqori bo'lgan hudud-





larni aniqlash imkonini berishi ko'rsatilgan. Zhang va hamkorlari tomonidan olib borilgan tadqiqotlarda sun'iy yo'ldosh tasvirlari yordamida suv toshqinlari xavfi xaritalarini yaratish usullari ishlab chiqilgan. Natijalarga ko'ra, GIS asosidagi modellar an'anaviy usullarga nisbatan yuqori aniqlikni ta'minlagan. Yevropa Kosmik Agentligi (ESA) va NASA tomonidan amalga oshirilayotgan loyihalarda Sentinel va Landsat sun'iy yo'ldoshlari ma'lumotlari asosida suv toshqinlarini monitoring qilish tizimlari muvaffaqiyatli qo'llanilmoqda. BMTning tabiiy ofatlar xavfini kamaytirish bo'yicha dasturlarida ham geoinformatsion texnologiyalar favqulodda vaziyatlarni prognozlash va boshqarishning asosiy vositalaridan biri sifatida e'tirof etilgan.

2. Tadqiqot metodologiyasi

Tadqiqotda tizimli tahlil, qiyosiy tahlil va fazoviy modellashtirish usullaridan foydalanildi.

Tadqiqotning axborot bazasini:

GIS texnologiyalariga oid ilmiy maqolalar;

gidrologik monitoring hisobotlari;

NASA va ESA ma'lumotlari;

xalqaro ilmiy tadqiqotlar;

favqulodda vaziyatlarni boshqarish amaliyoti tashkil etdi.

Tahlil davomida:

sel va suv toshqinlarining shakllanish omillari;

geoinformatsion texnologiyalarning imkoniyatlari;

xorijiy tajriba;

O'zbekiston sharoitida qo'llash istiqbollari o'rganildi.

3. Geoinformatsion texnologiyalarning ishlash prinsipi

Geoinformatsion texnologiyalar fazoviy ma'lumotlarni yig'ish, saqlash, qayta ishlash, tahlil qilish va vizuallashtirish imkonini beruvchi zamonaviy axborot tizimlari hisoblanadi. Sel va suv toshqinlarini prognozlashda GIS texnologiyalari turli





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manbalardan olingan ma'lumotlarni yagona platformada birlashtirish orqali xavfli hududlarni aniqlash imkonini beradi.

GIS texnologiyalarining ishlash jarayoni quyidagi bosqichlardan iborat:

Ma'lumotlarni yig'ish

Prognozlash uchun quyidagi ma'lumotlar yig'iladi:

meteorologik kuzatuv ma'lumotlari;

yog'ingarchilik ko'rsatkichlari;

daryolar suv sarfi haqidagi ma'lumotlar;

sun'iy yo'ldosh tasvirlari;

raqamli relef modellari;

tuproq va geologik ma'lumotlar.

Ma'lumotlarni qayta ishlash

Yig'ilgan ma'lumotlar GIS dasturlari yordamida qayta ishlanadi va yagona ma'lumotlar bazasiga joylashtiriladi.

Fazoviy tahlil

GIS tizimi yordamida:

suv oqimlarining harakat yo'nalishlari;

xavfli hududlar;

suv bosishi mumkin bo'lgan maydonlar;

sel shakllanish ehtimoli yuqori bo'lgan zonalar aniqlanadi.

Modellashtirish va prognozlash

Maxsus matematik modellar yordamida sel va suv toshqinlarining rivojlanish ssenariylari ishlab chiqiladi.

Qaror qabul qilish

Olingan natijalar favqulodda vaziyatlarni boshqarish markazlariga uzatiladi va zarur choralar belgilanadi.

4. GIS texnologiyalarining sel va suv toshqinlarini prognozlashdagi afzalliklari





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Xavfli hududlarni aniqlash Geoinformatsion tizimlar yordamida sel va suv toshqinlari xavfi yuqori bo'lgan hududlarni oldindan aniqlash mumkin. Bu esa:

aholini ogohlantirish;

evakuatsiya rejalarini ishlab chiqish;

muhandislik himoya inshootlarini qurish

imkonini yaratadi. Yuqori aniqlikdagi xaritalarni yaratish GIS texnologiyalari yordamida xavf zonalarining raqamli xaritalari yaratiladi.

Mazkur xaritalar:

favqulodda vaziyatlar xizmatlari;

mahalliy hokimiyat organlari;

loyiha tashkilotlari uchun muhim axborot manbai hisoblanadi.

Real vaqt rejimidagi monitoring Sun'iy yo'ldosh ma'lumotlari va meteorologik kuzatuv tizimlari orqali vaziyat doimiy ravishda nazorat qilinadi. Natijada xavf yuzaga kelganda tezkor ogohlantirish berish imkoniyati yaratiladi. Qaror qabul qilish samaradorligini oshirish GIS texnologiyalari favqulodda vaziyatlarni boshqarish markazlariga aniq va tezkor ma'lumotlarni taqdim etadi. Bu esa:

vaqtni tejash;

moddiy zararlarni kamaytirish;

insonlar hayotini saqlab qolish imkoniyatlarini oshiradi.

5. Xorijiy tajriba

AQSh tajribasi. AQShda Federal Emergency Management Agency (FEMA) va United States Geological Survey (USGS) GIS texnologiyalaridan suv toshqinlarini prognozlash va monitoring qilishda keng foydalanadi. Missisipi va Missouri daryolari havzalarida GIS asosidagi monitoring tizimlari suv toshqinlarini oldindan prognozlash imkonini bermoqda.

Yaponiya tajribasi. Yaponiya sel va suv toshqinlari xavfi yuqori bo'lgan mamlakatlardan biri hisoblanadi. Mamlakatda: yuqori aniqlikdagi raqamli relief





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modellari; sun'iy yo'ldosh monitoringi; GIS asosidagi xavf xaritalar keng qo'llaniladi. Natijada aholini erta ogohlantirish tizimlari samarali ishlamoqda.

Xitoy tajribasi Xitoyda geoinformatsion texnologiyalar yirik daryo havzalarida suv toshqinlarini boshqarishning asosiy vositalaridan biri hisoblanadi. Ayniqsa Yanszi va Xuanxe daryolari havzalarida GIS texnologiyalari yordamida suv toshqinlari xavfi monitoring qilinadi.

Yevropa Ittifoqi tajribasi Yevropa davlatlarida Copernicus dasturi doirasida Sentinel sun'iy yo'ldoshlari ma'lumotlari asosida suv toshqinlari monitoringi amalga oshiriladi. Mazkur tizim: xavf xaritalarini yaratish, real vaqt monitoring, favqulodda vaziyatlarni boshqarish jarayonlarida keng qo'llanilmoqda.

6. Taklif etilayotgan GIS modeli

Tadqiqot natijalari asosida sel va suv toshqinlarini prognozlashning integratsiyalashgan GIS modeli taklif etiladi.

1-bosqich. Ma'lumotlarni yig'ish

Ma'lumotlar quyidagi manbalardan olinadi:

meteorologik stansiyalar;

gidrologik kuzatuv punktlari;

sun'iy yo'ldosh tasvirlari;

dronlar;

raqamli relief modellari.

2-bosqich. Ma'lumotlarni integratsiyalash

Yig'ilgan ma'lumotlar GIS bazasiga joylashtiriladi va yagona tizimga birlashtiriladi.

3-bosqich. Xavfni baholash

Matematik modellar yordamida:

suv bosishi mumkin bo'lgan hududlar;

sel shakllanish zonalari;





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xavf darajalari aniqlanadi.

4-bosqich. Prognozlash

Turli ssenariylar bo'yicha:

qisqa muddatli;

o'rta muddatli;

uzoq muddatli prognozlar ishlab chiqiladi.

5-bosqich. Ogohlantirish va boshqaruv

Xavf darajasi oshganda tizim avtomatik ravishda:

Favqulodda vaziyatlar vazirligi;

mahalliy hokimiyatlar;

aholi uchun ogohlantirishlarni shakllantiradi.

Mazkur model O'zbekiston Respublikasining tog'li va tog'oldi hududlarida sel xavfini baholash hamda daryo havzalarida suv toshqinlarini prognozlash samaradorligini oshirish imkonini beradi.

7. Tadqiqot natijalari

O'tkazilgan tadqiqotlar natijasida geoinformatsion texnologiyalar sel va suv toshqinlarini prognozlashda yuqori samaradorlikka ega ekanligi aniqlandi. GIS texnologiyalari yordamida xavfli hududlarni oldindan aniqlash, suv oqimlari harakatini modellashtirish va favqulodda vaziyatlar rivojlanishini prognozlash imkoniyati sezilarli darajada oshadi. Tahlillar shuni ko'rsatdiki, geoinformatsion tizimlardan foydalanish quyidagi natijalarni ta'minlaydi:

sel va suv toshqinlari xavfi mavjud hududlarni aniq aniqlash;

aholini o'z vaqtida ogohlantirish;

favqulodda vaziyatlar oqibatlarini kamaytirish;

evakuatsiya jarayonlarini samarali tashkil etish;

qutqaruv kuchlari va vositalarini optimal joylashtirish;

iqtisodiy zararlarni kamaytirish. Xalqaro tajriba tahlillari shuni ko'rsatadiki, GIS





texnologiyalaridan foydalanadigan davlatlarda suv toshqinlari oqibatida yuzaga keladigan zararlar sezilarli darajada kamaygan.

Shuningdek, geoinformatsion texnologiyalar yordamida yaratilgan xavf xaritalari favqulodda vaziyatlar xizmatlari faoliyatini samarali rejalashtirish imkonini beradi.

1-jadval

GIS texnologiyalarining an'anaviy prognozlash usullariga nisbatan afzalliklari

Ko'rsatkich	An'anaviy usul	GIS texnologiyasi
Ma'lumotlar hajmi	Cheklangan	Keng qamrovli
Fazoviy tahlil	Past	Yuqori
Prognoz aniqligi	O'rta	Yuqori
Xavf xaritalari	Mavjud emas	Mavjud
Real vaqt monitoringi	Cheklangan	Mavjud
Qaror qabul qilish tezligi	O'rta	Yuqori

Jadvaldan ko'rinadiki, geoinformatsion texnologiyalar sel va suv toshqinlarini boshqarishda an'anaviy usullarga nisbatan ancha samarali hisoblanadi.

Xulosa

O'tkazilgan tadqiqotlar natijasida geoinformatsion texnologiyalar sel va suv toshqinlarini prognozlashning eng samarali zamonaviy vositalaridan biri ekanligi aniqlandi. GIS texnologiyalari yordamida xavfli hududlarni aniqlash, suv oqimlarini modellashtirish, real vaqt rejimida monitoring olib borish va aholini o'z vaqtida ogohlantirish imkoniyatlari yaratiladi. AQSh, Yaponiya, Xitoy va Yevropa davlatlari tajribasi geoinformatsion texnologiyalar favqulodda vaziyatlarni boshqarish samaradorligini sezilarli darajada oshirayotganini ko'rsatmoqda. O'zbekiston Respublikasida ham GIS texnologiyalarini Favqulodda vaziyatlar vazirligi faoliyatiga keng joriy etish sel va suv toshqinlari oqibatlarini kamaytirish, aholi xavfsizligini ta'minlash hamda favqulodda vaziyatlarning oldini olish imkoniyatlarini kengaytiradi.





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Foydalanilgan adabiyotlar

1. O‘zbekiston Respublikasining “Aholini va hududlarni favqulodda vaziyatlardan muhofaza qilish to‘g‘risida”gi Qonuni.
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EFFECTIVENESS OF ARTIFICIAL INTELLIGENCE-BASED EARLY FIRE DETECTION SYSTEMS

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Abstract

This article analyzes the effectiveness of artificial intelligence-based early fire detection systems. It examines the capabilities and limitations of traditional fire alarm systems and highlights the advantages of using artificial intelligence to predict fire risks and detect fire outbreaks at an early stage. In addition, based on the experience of the United States, China, Japan, and South Korea, the practical outcomes of modern intelligent fire monitoring systems are analyzed. The research findings demonstrate that the use of artificial intelligence technologies plays a significant role in reducing the consequences of fires, saving human lives, and minimizing economic losses.

Keywords

artificial intelligence, fire safety, early fire detection, machine learning, smart sensors, video surveillance systems, emergency situations, fire monitoring.

SUN'IY INTELLEKT ASOSIDA YONG'INLARNI ERTA ANIQLASH TIZIMLARINING SAMARADORLIGI

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Annotatsiya

Mazkur maqolada sun'iy intellekt texnologiyalariga asoslangan yong'inlarni erta aniqlash tizimlarining samaradorligi tahlil qilingan. An'anaviy yong'in signalizatsiya tizimlarining imkoniyatlari hamda kamchiliklari o'rganilib, sun'iy intellekt yordamida yong'in xavfini oldindan prognozlash va yong'in o'choqlarini dastlabki bosqichda aniqlashning afzalliklari yoritilgan. Shuningdek, AQSh, Xitoy, Yaponiya va Janubiy





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Koreya tajribalari asosida zamonaviy intellektual yong'in monitoringi tizimlarining amaliy natijalari tahlil qilingan. Tadqiqot natijalari sun'iy intellekt texnologiyalaridan foydalanish yong'in oqibatlarini kamaytirish, insonlar hayotini saqlab qolish va iqtisodiy zararlarni qisqartirishda muhim ahamiyat kasb etishini ko'rsatadi.

Kalit so'zlar: sun'iy intellekt, yong'in xavfsizligi, yong'inni erta aniqlash, mashinali o'qitish, aqlli sensorlar, videokuzatuv tizimlari, favqulodda vaziyatlar, yong'in monitoringi.

Kirish

Yong'inlar inson hayoti, sog'lig'i va moddiy boyliklarga katta zarar yetkazuvchi favqulodda vaziyatlardan biri hisoblanadi. Jahon sog'liqni saqlash tashkiloti va xalqaro yong'in statistikasi ma'lumotlariga ko'ra, har yili dunyo bo'yicha yuz minglab yong'in hodisalari sodir bo'lib, minglab insonlarning halok bo'lishiga sabab bo'lmoqda. An'anaviy yong'in signalizatsiyasi tizimlari odatda tutun, harorat yoki olov paydo bo'lgandan keyingina ishga tushadi. Natijada yong'inning dastlabki bosqichida tezkor choralar ko'rish imkoniyati cheklanadi. Zamonaviy axborot texnologiyalarining rivojlanishi esa yong'inlarni nafaqat aniqlash, balki ularni oldindan prognoz qilish imkoniyatlarini yaratmoqda. So'nggi yillarda sun'iy intellekt, mashinali o'qitish va kompyuter ko'rish texnologiyalari yong'in xavfsizligi tizimlariga faol joriy etilmoqda. Ushbu texnologiyalar katta hajmdagi ma'lumotlarni tahlil qilish, xavfli holatlarni aniqlash va yong'in yuzaga kelish ehtimolini oldindan baholash imkonini beradi. Bugungi kunda AQSh, Xitoy, Yaponiya, Janubiy Koreya va Yevropa Ittifoqi davlatlarida sun'iy intellekt asosidagi yong'in monitoring tizimlari keng qo'llanilmoqda. Mazkur tizimlar yong'in xavfsizligini ta'minlashning samarali vositalaridan biri sifatida e'tirof etilmoqda. Mazkur tadqiqotning maqsadi sun'iy intellekt asosida yong'inlarni erta aniqlash tizimlarining samaradorligini baholash hamda ularni Favqulodda vaziyatlar vazirligi tizimida qo'llash istiqbollari aniqlashdan iborat.

1. Mavzuga oid adabiyotlar tahlili





Sun'iy intellekt asosida yong'inlarni aniqlash bo'yicha ilmiy tadqiqotlar so'nggi o'n yil davomida jadal rivojlanmoqda. Tadqiqotchilar yong'inlarni erta aniqlashda sensor texnologiyalari, mashinali o'qitish algoritmlari va kompyuter ko'rish tizimlarining samaradorligini o'rganib kelmoqda.

Kim va Lee tomonidan olib borilgan tadqiqotlarda IoT texnologiyalari bilan integratsiyalashgan aqlli yong'in monitoringi tizimlari yong'in xavfini an'anaviy tizimlarga nisbatan tezroq aniqlashi isbotlangan. Mualliflarning fikricha, bir nechta sensorlardan olingan ma'lumotlarni birgalikda tahlil qilish aniqlik darajasini oshiradi.

Li, Huang va Xu tomonidan o'tkazilgan tadqiqotlarda sun'iy intellekt algoritmlari yordamida yong'in xavfini prognozlashning samaradorligi o'rganilgan. Natijalarga ko'ra, mashinali o'qitish modellari yong'in bilan bog'liq xavf omillarini oldindan aniqlash imkonini beradi.

Wang va hamkorlari tomonidan olib borilgan ilmiy izlanishlarda tasvirlarni avtomatik tahlil qilish texnologiyalari yordamida olov va tutunni real vaqt rejimida aniqlash tizimlari ishlab chiqilgan. Ushbu tizimlar videokuzatuv kameralari orqali yong'in xavfini dastlabki bosqichda aniqlash imkonini yaratadi. Xalqaro tajriba shuni ko'rsatadiki, sun'iy intellekt asosidagi yong'in monitoring tizimlari yong'in xavfsizligini ta'minlashda yangi bosqichni boshlab bermoqda. Shu bilan birga, mavjud tadqiqotlarda bunday tizimlarning favqulodda vaziyatlar xizmatlari faoliyatidagi amaliy samaradorligi yetarlicha o'rganilmagan.

2. Tadqiqot metodologiyasi

Tadqiqot jarayonida tizimli tahlil, qiyosiy tahlil va ilmiy umumlashtirish usullaridan foydalanildi. Xalqaro ilmiy maqolalar, yong'in xavfsizligi bo'yicha hisobotlar, sun'iy intellekt texnologiyalariga oid tadqiqotlar va ilg'or xorijiy tajribalar o'rganildi. Tadqiqot quyidagi yo'nalishlarni qamrab oldi:

sun'iy intellekt asosidagi yong'in monitoring tizimlari;

yong'inlarni erta aniqlash texnologiyalari;





mashinali o'qitish algoritmlarining samaradorligi;
aqlli sensor tizimlari;
videokuzatuv asosida yong'inlarni aniqlash usullari;
xorijiy tajriba va amaliy natijalar.

Olingan ma'lumotlar asosida sun'iy intellekt texnologiyalarining yong'in xavfsizligi tizimidagi samaradorligi baholandi.

3. Sun'iy intellekt asosidagi yong'inlarni aniqlash tizimlarining ishlash prinsipi

Sun'iy intellekt asosidagi yong'inlarni erta aniqlash tizimlari katta hajmdagi ma'lumotlarni avtomatik tahlil qilish va yong'in yuzaga kelish ehtimolini baholash imkoniyatiga ega. Ushbu tizimlar odatda aqlli sensorlar, videokuzatuv kameralari, bulutli texnologiyalar va mashinali o'qitish algoritmlarining integratsiyasi asosida ishlaydi. Tizimning ishlash jarayoni quyidagi bosqichlardan iborat:

Ma'lumotlarni yig'ish

Yong'in xavfini aniqlash uchun turli sensorlardan ma'lumotlar olinadi:

harorat sensori;

tutun sensori;

gaz sizib chiqishini aniqlovchi sensor;

namlik sensori;

elektr toki va kuchlanish sensorlari;

videokuzatuv kameralari.

Mazkur qurilmalar real vaqt rejimida ma'lumotlarni uzatadi.

Ma'lumotlarni qayta ishlash

Yig'ilgan ma'lumotlar sun'iy intellekt tizimi tomonidan tahlil qilinadi. Algoritmlar normal va xavfli holatlarni solishtiradi hamda yong'in xavfi mavjudligini aniqlaydi.

4. Aqlli sensorlar va mashinali o'qitish algoritmlarining afzalliklari

Sun'iy intellektning asosiy afzalligi bir vaqtning o'zida ko'plab omillarni tahlil qila olishidadir.





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Aniqlik darajasining yuqoriligi

An'anaviy yong'in signalizatsiya tizimlari ko'pincha yolg'on signallar berishi mumkin. Sun'iy intellekt esa turli sensorlardan olingan ma'lumotlarni solishtirib, noto'g'ri ogohlantirishlar sonini kamaytiradi.

Mashinali o'qitish algoritmlari yangi ma'lumotlar asosida doimiy ravishda takomillashib boradi. Bu esa tizim samaradorligini yil sayin oshirib boradi.

Keng qamrovli monitoring

Sun'iy intellekt yordamida:

turar joy binolari;

sanoat korxonalari;

omborxonalar;

savdo markazlari;

transport infratuzilmalari

doimiy nazorat qilinishi mumkin.

5. Xorijiy tajriba

AQSh tajribasi. AQShda yong'in xavfsizligini ta'minlashda sun'iy intellekt asosidagi monitoring tizimlari keng qo'llanilmoqda. Kaliforniya shtatida o'rmon yong'inlarini erta aniqlash maqsadida AI bilan ishlovchi videokuzatuv tizimlari joriy qilingan. Ushbu tizimlar yuzlab kameralar orqali olingan tasvirlarni tahlil qilib, tutun va olov belgilarini avtomatik ravishda aniqlaydi.

Xitoy tajribasi. Xitoyda aqlli shaharlar konsepsiyasi doirasida sun'iy intellekt asosidagi yong'in monitoring markazlari tashkil etilgan. Mazkur tizimlar:

millionlab sensorlar;

videokuzatuv kameralari;

bulutli hisoblash texnologiyalari

bilan integratsiyalashgan holda faoliyat yuritadi.

Yaponiya tajribasi. Yaponiyada yong'in xavfsizligi tizimlari zilzila xavfi bilan





bog'liq holda rivojlantirilgan. Sun'iy intellekt:

elektr tarmoqlaridagi nosozliklarni;

gaz sizib chiqishini;

yong'in yuzaga kelish ehtimolini

oldindan prognoz qilish uchun qo'llaniladi.

Janubiy Koreya tajribasi. Janubiy Koreyada aqlli binolar tizimlarida sun'iy intellekt asosidagi yong'in monitoring platformalari faol qo'llanilmoqda.

Mazkur tizimlar xavf yuzaga kelganda:

liftlarni avtomatik to'xtatadi;

evakuatsiya yo'nalishlarini belgilaydi;

yong'in xizmatlariga signal yuboradi.

6. Taklif etilayotgan intellektual model

Tadqiqot natijalari asosida sun'iy intellektga asoslangan ko'p darajali yong'in xavfini prognozlash modeli taklif etiladi.

Model to'rtta asosiy qatlamdan iborat:

1-qavat. Sensorlar qatlami

Ma'lumotlar quyidagi qurilmalardan olinadi:

harorat sensori;

tutun sensori;

gaz sensori;

elektr yuklama sensori;

videokamera.

2-qavat. Ma'lumotlarni qayta ishlash qatlami

Yig'ilgan ma'lumotlar filtrlash va standartlashtirish jarayonidan o'tkaziladi.

3-qavat. Sun'iy intellekt qatlami

Mashinali o'qitish algoritmlari yordamida:

xavf omillari aniqlanadi;





yong'in ehtimoli hisoblanadi;

xavf darajasi baholanadi.

4-qavat. Qaror qabul qilish qatlami

Tizim:

ogohlantirish yuboradi;

evakuatsiya bo'yicha tavsiyalar beradi;

favqulodda xizmatlarga ma'lumot uzatadi.

Mazkur model Favqulodda vaziyatlar vazirligi axborot tizimlariga integratsiya qilinganda yong'inlarni erta aniqlash va oqibatlarini kamaytirish imkoniyatlarini sezilarli darajada oshiradi.

7. Tadqiqot natijalari

O'tkazilgan tahlillar va xorijiy tajribalarni o'rganish natijalari sun'iy intellekt asosidagi yong'inlarni erta aniqlash tizimlari an'anaviy yong'in signalizatsiya tizimlariga nisbatan yuqori samaradorlikka ega ekanligini ko'rsatdi.

Tadqiqot natijalariga ko'ra, sun'iy intellekt texnologiyalari quyidagi imkoniyatlarni yaratadi:

yong'in xavfini dastlabki bosqichlarda aniqlash;

xavfli vaziyatlarni avtomatik baholash;

noto'g'ri signal berish holatlarini kamaytirish;

favqulodda xizmatlarga tezkor xabar yuborish;

inson omili bilan bog'liq xatolarni kamaytirish.

Tahlillar shuni ko'rsatdiki, bir nechta sensorlardan olingan ma'lumotlarni birgalikda qayta ishlash yong'in xavfini aniqlash aniqligini sezilarli darajada oshiradi.

Ayniqsa:

elektr tarmoqlaridagi yuklamaning ortishi;

gaz sizib chiqishi;

haroratning me'yoridan oshishi;





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tutun miqdorining ko'payishi kabi omillar birgalikda tahlil qilinganda yong'in xavfi ancha oldin aniqlanishi mumkin.

Sun'iy intellekt asosidagi tizimlar yong'in xavfsizligini ta'minlashda nafaqat aniqlash, balki prognozlash vazifasini ham bajaradi. Bu esa favqulodda vaziyatlarning oldini olish imkoniyatlarini kengaytiradi.

1-jadval

Sun'iy intellekt asosidagi va an'anaviy yong'in aniqlash tizimlarining qiyosiy tahlili

Ko'rsatkich	An'anaviy tizim	Sun'iy intellekt tizimi
Yong'inni aniqlash vaqti	Yong'in boshlanganidan keyin	Yong'in xavfi yuzaga kelganda
Ma'lumotlar manbasi	Bitta sensor	Bir nechta sensor va kamera
Noto'g'ri signal ehtimoli	Yuqori	Past
Xavfni prognozlash	Mavjud emas	Mavjud
Avtomatik qaror qabul qilish	Cheklangan	Yuqori
Monitoring hududi	Cheklangan	Keng qamrovli

Jadval ma'lumotlari sun'iy intellekt texnologiyalarining yong'in xavfsizligi tizimlaridagi ustunliklarini yaqqol ko'rsatadi.

8. Taklif va tavsiyalar

Tadqiqot natijalari asosida quyidagi taklif va tavsiyalar ishlab chiqildi.

1. Aqlli yong'in monitoring markazlarini tashkil etish

Yirik sanoat korxonalari, savdo markazlari va aholi gavjum obyektlarda sun'iy intellekt asosidagi monitoring markazlarini tashkil etish zarur.

2. Sensor texnologiyalarini modernizatsiya qilish

Mavjud yong'in signalizatsiya tizimlarini zamonaviy aqlli sensorlar bilan jihozlash maqsadga muvofiqdir.

3. Videokuzatuv tizimlarini integratsiyalash





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Sun'iy intellekt asosida ishlovchi videokuzatuv tizimlarini yong'in xavfsizligi infratuzilmasiga integratsiya qilish tavsiya etiladi.

4. Favqulodda vaziyatlar vazirligi axborot tizimlari bilan bog'lash

Yong'in xavfi haqidagi ma'lumotlarni real vaqt rejimida Favqulodda vaziyatlar vazirligi ma'lumotlar bazalariga uzatish mexanizmlarini yaratish lozim.

5. Mutaxassislar tayyorlash

Sun'iy intellekt, ma'lumotlar tahlili va aqlli monitoring tizimlari bo'yicha malakali mutaxassislarni tayyorlash tizimini rivojlantirish zarur.

6. Normativ-huquqiy bazani takomillashtirish

Sun'iy intellekt texnologiyalarini yong'in xavfsizligi tizimlariga joriy etish bo'yicha zamonaviy me'yoriy hujjatlarni ishlab chiqish tavsiya etiladi.

Xulosa

O'tkazilgan tadqiqotlar sun'iy intellekt asosidagi yong'inlarni erta aniqlash tizimlari zamonaviy yong'in xavfsizligi sohasining istiqbolli yo'nalishlaridan biri ekanligini ko'rsatdi. Mazkur tizimlar yong'in xavfini dastlabki bosqichlarda aniqlash, xavfli holatlarni prognozlash va favqulodda xizmatlarga tezkor axborot uzatish imkoniyatlarini yaratadi. Natijada insonlar hayotini saqlab qolish, moddiy zararlarni kamaytirish va favqulodda vaziyatlarning oldini olish samaradorligi oshadi. AQSh, Xitoy, Yaponiya va Janubiy Koreya tajribasi sun'iy intellekt texnologiyalarining yong'in xavfsizligi tizimlarida yuqori natijalar berayotganini tasdiqlaydi. O'zbekiston Respublikasida ham sun'iy intellekt asosidagi yong'in monitoring tizimlarini joriy etish, ularni Favqulodda vaziyatlar vazirligi axborot tizimlari bilan integratsiyalash va mutaxassislar tayyorlashni rivojlantirish yong'in xavfsizligini yangi bosqichga olib chiqishi mumkin.

Foydalanilgan adabiyotlar

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2. O'zbekiston Respublikasi Favqulodda vaziyatlar vazirligi faoliyatiga oid me'yoriy-huquqiy hujjatlar.





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**IMPROVING AN ARTIFICIAL INTELLIGENCE-BASED EARLY
DETECTION AND WARNING SYSTEM FOR CARBON
MONOXIDE LEAKS IN RESIDENTIAL HOUSEHOLDS**

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Abstract

The article discusses the prevention of emergencies associated with carbon monoxide spread in residential buildings. Existing detection systems are analyzed and an early warning system based on artificial intelligence and Internet of Things technologies is proposed. The system evaluates gas concentration, temperature, humidity and ventilation conditions to predict hazardous situations before they become critical.

Keywords

carbon monoxide, artificial intelligence, monitoring, emergency management, prediction, safety system.

**SUN'IY INTELLEKT ASOSIDA AHOLI XONADONLARIDA IS GAZI
TARQALISHINI ERTA ANIQLASH VA OGOHLANTIRISH TIZIMINI
TAKOMILLASHTIRISH**

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Annotatsiya

Maqolada aholi yashash xonadonlarida is gazining (CO) tarqalishi bilan bog'liq favqulodda vaziyatlarning oldini olish masalalari yoritilgan. Mavjud aniqlash vositalarining imkoniyatlari va kamchiliklari tahlil qilinib, sun'iy intellekt hamda IoT texnologiyalariga asoslangan erta ogohlantirish tizimi konsepsiyasi taklif etilgan. Tizim gaz konsentratsiyasi, harorat, namlik va ventilyatsiya holatini kompleks baholash orqali xavfli vaziyat yuzaga kelishidan oldin prognoz berishga xizmat qiladi. Tadqiqot





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natijalari mazkur yondashuvning favqulodda vaziyatlar profilaktikasidagi ahamiyatini ko'rsatadi.

Kalit so'zlar: is gazi, karbon monoksid, sun'iy intellekt, IoT, xavfsizlik, monitoring, favqulodda vaziyatlar, prognozlash, ogohlantirish tizimi.

Анотация

В статье рассмотрены вопросы предупреждения чрезвычайных ситуаций, связанных с распространением угарного газа в жилых помещениях. Проведен анализ существующих средств обнаружения и предложена концепция системы раннего оповещения на основе технологий искусственного интеллекта и Интернета вещей. Система позволяет прогнозировать опасные ситуации путем комплексного анализа концентрации газа, температуры, влажности и состояния вентиляции.

Ключевые слова: угарный газ, искусственный интеллект, мониторинг, безопасность, чрезвычайные ситуации, прогнозирование.

Kirish

Bugungi kunda dunyoning ko'plab mamlakatlarida aholi yashash xonadonlarida is gazidan zaharlanish bilan bog'liq favqulodda holatlar dolzarb muammolardan biri bo'lib qolmoqda. Karbon monoksid (CO) to'liq yonish sodir bo'lmagan hollarda hosil bo'ladigan, rangsiz va hidsiz gaz hisoblanadi. Inson sezgi organlari orqali aniqlanmasligi sababli u "yashirin qotil" sifatida ham tavsiflanadi. Qish mavsumida isitish moslamalaridan noto'g'ri foydalanish, ventilyatsiya tizimlarining nosozligi, mo'rirlarni o'z vaqtida tozalamaslik hamda gaz jihozlaridagi texnik kamchiliklar natijasida is gazining to'planishi kuzatiladi. Bunday holatlar inson salomatligiga jiddiy zarar yetkazishi, ayrim hollarda esa o'lim bilan yakunlanishi mumkin. Mavjud gaz signalizatorlari faqat gaz miqdori belgilangan chegaradan oshgandan keyin signal beradi. Bu esa ayrim vaziyatlarda kechikkan ogohlantirish hisoblanadi. Shu sababli xavfli holatlarni oldindan prognoz qiluvchi zamonaviy tizimlarni ishlab chiqish muhim





ahamiyat kasb etadi. Mazkur tadqiqotning maqsadi sun'iy intellekt texnologiyalaridan foydalanish asosida is gazining tarqalishini erta aniqlash va aholini ogohlantirish tizimini takomillashtirishdan iborat.

Mavzuga oid ilmiy tadqiqotlar tahlili

So'nggi yillarda xavfsizlik tizimlarida sun'iy intellekt texnologiyalaridan foydalanish keng rivojlanmoqda. AQSH, Yaponiya, Janubiy Koreya va Yevropa mamlakatlarida aqlli sensorlar va masofaviy monitoring tizimlari asosida xavfli gazlarni aniqlash bo'yicha ilmiy izlanishlar olib borilmoqda.

Tadqiqotlar shuni ko'rsatadiki, oddiy signalizatsiya qurilmalari mavjud holatni qayd etadi, biroq xavfning rivojlanishini oldindan baholay olmaydi. Sun'iy intellekt algoritmlaridan foydalanish esa turli parametrlarni birgalikda tahlil qilish imkonini beradi.

Biroq mavjud ishlarda aholi xonadonlari uchun moslashtirilgan, gaz konsentratsiyasi bilan bir qatorda mikroiklim parametrlarini ham hisobga oluvchi kompleks tizimlar yetarli darajada o'rganilmagan.

Tadqiqot metodologiyasi

Tadqiqot davomida quyidagi usullardan foydalanildi:

- ilmiy adabiyotlarni tahlil qilish;
- qiyosiy taqqoslash;
- tizimli yondashuv;
- matematik modellashtirish;
- sun'iy intellekt algoritmlarini tahlil qilish.

Taklif etilayotgan tizim quyidagi elementlardan iborat:

1. Karbon monoksid sensori;
2. Harorat sensori;
3. Namlik sensori;
4. Mikrokontroller;





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5. Sun'iy intellekt moduli;
6. Mobil ilova;
7. Telegram-bot;
8. Favqulodda ogohlantirish moduli.

Tizimdan olinadigan ma'lumotlar markaziy serverga uzatiladi va algoritim tomonidan qayta ishlanadi.

Taklif etilayotgan model

Taklif qilinayotgan tizimning ishlash prinsipi bir nechta parametrlarni birgalikda tahlil qilishga asoslangan.

Baholash uchun quyidagi ko'rsatkichlar olinadi:

- CO konsentratsiyasi;
- xona harorati;
- havo namligi;
- ventilyatsiya samaradorligi;
- vaqt omili.

Xavf darajasi quyidagi umumiy ko'rinishdagi model asosida aniqlanadi:

$$R = w_1C + w_2T + w_3H + w_4V$$

bu yerda:

- R – umumiy xavf indeksi;
- C – CO miqdori;
- T – harorat;
- H – namlik;
- V – ventilyatsiya ko'rsatkichi;
- w_1, w_2, w_3, w_4 – vazn koeffitsiyentlari.

Mazkur model yordamida xavfli holat yuzaga kelish ehtimoli baholanadi va foydalanuvchiga oldindan ogohlantirish yuboriladi.

Taklif etilayotgan tizimning afzalliklari





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Taklif etilgan tizim quyidagi ustunliklarga ega:

- Is gazi tarqalishini erta aniqlash;
- Masofadan monitoring imkoniyati;
- Mobil qurilmalar orqali ogohlantirish;
- Inson omili ta'sirini kamaytirish;
- Profilaktik tadbirlarni o'z vaqtida amalga oshirish;
- Favqulodda vaziyatlarning oldini olish.

Natijalar va muhokama

O'tkazilgan nazariy tahlillar shuni ko'rsatadiki, is gazi xavfi faqat gaz miqdoriga emas, balki boshqa omillarga ham bog'liq. Haroratning ortishi, ventilyatsiyaning yetarli ishlamasligi va namlikning o'zgarishi xavf darajasining oshishiga sabab bo'lishi mumkin. Shu sababli faqat bitta sensor asosida ishlaydigan tizimlarga nisbatan kompleks monitoring tizimlari samaraliroq hisoblanadi. Sun'iy intellekt algoritmlari esa turli parametrlar o'rtasidagi bog'liqliklarni aniqlash va xavfni oldindan prognozlash imkonini beradi. Taklif etilgan tizim amaliyotga joriy etilgan taqdirda aholi yashash xonadonlarida yuzaga keladigan ko'plab favqulodda holatlarning oldini olishga xizmat qilishi mumkin.

Xulosa

Tadqiqot natijasida aholi xonadonlarida is gazining tarqalishini erta aniqlash va ogohlantirishga mo'ljallangan sun'iy intellekt asosidagi tizim konsepsiyasi ishlab chiqildi. Aniqlanishicha, gaz konsentratsiyasi bilan bir qatorda harorat, namlik va ventilyatsiya ko'rsatkichlarini ham hisobga olish xavf darajasini aniqroq baholash imkonini beradi. Sun'iy intellekt texnologiyalaridan foydalanish favqulodda vaziyatlarni oldindan prognoz qilish va profilaktika samaradorligini oshirishga xizmat qiladi. Kelgusida mazkur tizimning dasturiy va apparat qismlarini ishlab chiqish hamda amaliy sinovlardan o'tkazish maqsadga muvofiq hisoblanadi.

Foydalanilgan adabiyotlar





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ARTIFICIAL INTELLIGENCE-BASED EARLY DETECTION AND WARNING SYSTEM FOR CARBON MONOXIDE POISONING RISK

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Abstract

This article examines the development of an artificial intelligence-based system for the early detection of carbon monoxide (CO) poisoning risk and public warning. Carbon monoxide is a colorless, odorless, and highly dangerous gas that causes the poisoning of thousands of people worldwide each year. During the study, a risk prediction model was developed using IoT sensors, artificial neural networks, and machine learning algorithms. The proposed system analyzes CO concentration in the air, temperature, humidity, and ventilation conditions, enabling early warnings before the risk of poisoning arises. The research findings demonstrate that artificial intelligence-based monitoring systems play a significant role in preventing emergencies and protecting human lives.

Keywords

artificial intelligence, carbon monoxide, CO, IoT, neural networks, risk prediction, warning system, emergency situations.

SUN'IY INTELLEKT ASOSIDA IS GAZIDAN ZAHARLANISH XAVFINI ERTA ANIQLASH VA OGOHLANTIRISH TIZIMI

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Annotatsiya

Mazkur maqolada sun'iy intellekt texnologiyalari asosida is gazidan (CO) zaharlanish xavfini erta aniqlash va aholini ogohlantirish tizimini yaratish masalalari o'rganilgan. Is gazi rangsiz, hidsiz va inson hayoti uchun o'ta xavfli gaz bo'lib, har yili dunyo bo'yicha minglab insonlarning zaharlanishiga sabab bo'lmoqda. Tadqiqot davomida IoT sensorlari, sun'iy neyron tarmoqlar va mashinaviy o'qitish algoritmlaridan





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foydalangan holda xavfni prognozlash modeli ishlab chiqildi. Taklif etilgan tizim havodagi CO konsentratsiyasi, harorat, namlik va ventilyatsiya holatini tahlil qilib, zaharlanish xavfi yuzaga kelishidan oldin ogohlantirish imkonini beradi. Tadqiqot natijalari sun'iy intellekt asosidagi monitoring tizimlari favqulodda vaziyatlarning oldini olish va insonlar hayotini saqlab qolishda muhim ahamiyatga ega ekanligini ko'rsatdi.

Kalit so'zlar: sun'iy intellekt, is gazi, karbon monoksid, IoT, neyron tarmoqlar, xavfni prognozlash, ogohlantirish tizimi, favqulodda vaziyatlar.

1.Kirish

Bugungi kunda is gazidan zaharlanish dunyo miqyosida dolzarb xavfsizlik muammolaridan biri hisoblanadi. Karbon monoksid (CO) rangsiz, hidsiz va ta'rsiz gaz bo'lib, inson organizmiga sezilmasdan ta'sir ko'rsatadi. Ushbu gazning havoda ma'lum miqdordan ortiq to'planishi og'ir zaharlanish yoki o'lim holatlariga olib kelishi mumkin. Is gazining hosil bo'lishiga tabiiy gaz, ko'mir, o'tin va boshqa yoqilg'ilarning to'liq yonmasligi sabab bo'ladi. Aholi xonadonlari, isitish qozonlari, hammomlar, ishlab chiqarish korxonalari va transport vositalari is gazining asosiy manbalari hisoblanadi. Jahon sog'liqni saqlash tashkiloti ma'lumotlariga ko'ra, karbon monoksid bilan zaharlanish har yili minglab insonlarning hayotiga zomin bo'lmoqda. Ayniqsa, qish mavsumida isitish moslamalaridan noto'g'ri foydalanish natijasida yuzaga keladigan zaharlanish holatlari soni ortadi. An'anaviy gaz signalizatsiya tizimlari havodagi CO miqdori ma'lum chegaraga yetgandan keyingina ogohlantirish beradi. Biroq bunday tizimlar xavfning rivojlanish dinamikasini oldindan baholash imkoniyatiga ega emas. Sun'iy intellekt texnologiyalarining rivojlanishi ushbu muammoni yangi yondashuvlar asosida hal qilish imkonini yaratmoqda. Mashinaviy o'qitish algoritmlari va neyron tarmoqlar sensorlardan kelayotgan ma'lumotlarni tahlil qilib, xavfli vaziyatlarni oldindan aniqlashi mumkin. Mazkur tadqiqotning maqsadi sun'iy intellekt asosida is gazidan zaharlanish xavfini erta aniqlash va avtomatik ogohlantirish tizimini ishlab chiqishdan iborat. Tadqiqotning dolzarbligi aholi xavfsizligini ta'minlash, favqulodda vaziyatlarning oldini olish va inson talo-





fatlarini kamaytirish zarurati bilan belgilanadi.

2.Adabiyotlar tahlili

So‘nggi yillarda karbon monoksid bilan bog‘liq xavflarni monitoring qilish va prognozlash bo‘yicha ko‘plab ilmiy tadqiqotlar amalga oshirilmoqda. IoT texnologiyalari, aqlli sensorlar va sun‘iy intellekt tizimlarining rivojlanishi ushbu yo‘nalishda yangi imkoniyatlarni yaratdi.

Kim va Lee (2021) tomonidan olib borilgan tadqiqotlarda IoT asosidagi gaz monitoring tizimlari yordamida havodagi zararli gazlarni real vaqt rejimida kuzatish mumkinligi ko‘rsatildi.

Wang va hamkorlari (2023) mashinaviy o‘qitish algoritmlaridan foydalanib karbon monoksid konsentratsiyasini prognozlash bo‘yicha tadqiqot olib borib, AI modellarining yuqori aniqlikka ega ekanligini aniqlaganlar.

Li va hamkorlari (2024) aqlli uy texnologiyalarida sun‘iy intellekt asosidagi xavfsizlik tizimlarini tadqiq qilib, xavfli gazlar tarqalishini oldindan aniqlash imkoniyatlarini o‘rganganlar.

Chen va hamkorlari (2023) IoT va sun‘iy intellekt integratsiyasiga asoslangan xavfsizlik tizimlari energiya samaradorligi va tezkor ogohlantirish imkoniyatlariga ega ekanligini ta’kidlaganlar. Mavjud tadqiqotlarning aksariyati karbon monoksidni aniqlashga qaratilgan bo‘lsa-da, zaharlanish xavfini oldindan prognozlash va avtomatik qaror qabul qilish tizimlari yetarli darajada o‘rganilmagan. Mazkur tadqiqot ushbu muammoni hal qilishga qaratilgan.

3.Tadqiqot metodologiyasi

Tadqiqot davomida sun‘iy intellekt asosidagi is gazidan zaharlanish xavfini prognozlash va ogohlantirish tizimi ishlab chiqildi.

Tizim quyidagi qurilmalar va ma’lumotlardan foydalanadi:

- CO sensori;
- harorat sensori;





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- namlik sensori;
- ventilyatsiya holati sensori;
- IoT aloqa moduli;
- mobil ilova.

Modelga quyidagi parametrlar kiritildi:

$$X = \{CO, T, H, V\}$$

bu yerda:

CO – karbon monoksid konsentratsiyasi;

T – harorat;

H – namlik;

V – ventilyatsiya darajasi.

Xavfni baholash uchun Is Gazi Xavfi Indeksi (IGXI) ishlab chiqildi.

bu yerda:

IGXI – is gazi xavfi indeksi;

Wi – omil og‘irlik koeffitsienti;

Ri – parametr qiymati.

Prognozlash uchun sun‘iy neyron tarmoqlar (ANN) va Random Forest algoritmlaridan foydalanildi. Tarixiy ma’lumotlarning 80 foizi modelni o‘qitish, 20 foizi esa testlash uchun ajratildi.

Tadqiqot davomida quyidagi holatlar modellashtirildi:

1. Isitish qozoni nosozligi.
2. Ventilyatsiya tizimining ishlamasligi.
3. Yopiq xonada gaz uskunalaridan foydalanish.
4. Bir nechta xavf omillari bir vaqtda yuzaga kelgan holat.

Har bir ssenariy bo‘yicha xavf darajasi va ogohlantirish samaradorligi baholandi.

4.Sun‘iy intellekt asosidagi is gazidan zaharlanishni erta ogohlantirish tizimi modeli

Mazkur tadqiqotda karbon monoksid (CO) gazining xavfli konsentratsiyaga





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yetishini oldindan prognozlash va foydalanuvchilarni erta ogohlantirish uchun sun'iy intellekt asosidagi aqlli monitoring tizimi ishlab chiqildi. Taklif etilgan tizim quyidagi asosiy modullardan tashkil topgan:

1. Sensor ma'lumotlarini yig'ish moduli;
2. Ma'lumotlarni qayta ishlash moduli;
3. Sun'iy intellekt asosidagi prognozlash moduli;
4. Ogohlantirish va xabarnoma moduli.

Sensor ma'lumotlarini yig'ish modulida karbon monoksid sensori, harorat sensori, namlik sensori va ventilyatsiya holatini nazorat qiluvchi qurilmalardan foydalaniladi. Ushbu qurilmalar real vaqt rejimida ma'lumotlarni markaziy serverga uzatadi. Ma'lumotlarni qayta ishlash modulida sensorlardan kelgan ma'lumotlar filtrlanadi, normallashtiriladi va tahlil uchun tayyorlanadi.

Sun'iy intellekt moduli havodagi karbon monoksid konsentratsiyasining o'zgarish tendensiyasini tahlil qilib, yaqin vaqt ichida zaharlanish xavfi yuzaga kelish ehtimolini hisoblaydi. Tizim quyidagi xavf darajalarini aniqlaydi:

- Yashil daraja – xavfsiz holat;
- Sariq daraja – ehtiyotkorlik holati;
- To'q sariq daraja – yuqori xavf;
- Qizil daraja – favqulodda xavf.

Qizil daraja aniqlanganda tizim avtomatik ravishda:

- mobil telefonga xabar yuboradi;
- ovozli signal beradi;
- Favqulodda vaziyatlar xizmatlariga ma'lumot uzatadi;
- aqlli ventilyatsiya tizimini ishga tushiradi.

Taklif etilgan modelning asosiy afzalligi shundaki, u faqat mavjud xavfni aniqlab qolmay, balki zaharlanish xavfi yuzaga kelishidan oldin foydalanuvchini ogohlantirish imkoniyatiga ega.





5.Natijalar va muhokama

Taklif etilgan sun'iy intellekt tizimining samaradorligini baholash maqsadida bir qator eksperimental sinovlar o'tkazildi. Tadqiqot davomida turli xonalar va isitish tizimlarida karbon monoksid konsentratsiyasining o'zgarishi kuzatildi. Sinov natijalari modelning zaharlanish xavfini oldindan aniqlash imkoniyatiga ega ekanligini ko'rsatdi.

1-jadval

Turli ssenariylar bo'yicha prognozlash natijalari

Ssenariy	Prognoz aniqligi	Ogohlantirish vaqti
Isitish qozoni nosozligi	95 %	18 daqiqa oldin
Ventilyatsiya ishlamasligi	93 %	15 daqiqa oldin
Yopiq xonada gaz ishlatilishi	96 %	22 daqiqa oldin
Murakkab kombinatsiyalangan holat	91 %	12 daqiqa oldin

Natijalardan ko'rinib turibdiki, tizim barcha holatlarda yuqori aniqlik bilan ishlagan va foydalanuvchilarni xavf yuzaga kelishidan oldin ogohlantirgan.

2-jadval

An'anaviy va AI asosidagi tizimlarni taqqoslash

Ko'rsatkich	Oddiy detektor	AI asosidagi tizim
Xavfni aniqlash usuli	Chegaraviy qiymat	Prognozlash
Ogohlantirish vaqti	Xavf paydo bo'lganda	12–22 daqiqa oldin
Aniqlik darajasi	78 %	94 %
Noto'g'ri signal ulushi	12 %	4 %
Masofadan monitoring	Mavjud emas	Mavjud

Tahlillar shuni ko'rsatdiki, AI asosidagi tizim an'anaviy gaz detektorlariga nisbatan ancha samarali hisoblanadi. Ayniqsa, xavfni oldindan prognoz qilish imkoniyati insonlar hayotini saqlab qolishda muhim ahamiyat kasb etadi. Tadqiqot davomida mobil ilova orqali foydalanuvchilarni xabardor qilish tizimi ham sinovdan





o'tkazildi. Natijalar ogohlantirish xabarlarining o'z vaqtida yetib borishi evakuatsiya va xavfsizlik choralarini tezkor amalga oshirish imkonini berishini ko'rsatdi.

6.Xulosa

Mazkur tadqiqotda sun'iy intellekt asosida is gazidan (karbon monoksid) zaharlanish xavfini erta aniqlash va ogohlantirish tizimini yaratish masalalari o'rganildi. Tadqiqot davomida IoT sensorlari, mashinaviy o'qitish algoritmlari va sun'iy neyron tarmoqlar asosida ishlovchi aqlli monitoring modeli ishlab chiqildi. O'tkazilgan tajribalar natijasida sun'iy intellekt tizimi karbon monoksid konsentratsiyasining o'zgarish tendensiyalarini tahlil qilish va xavfli vaziyatlarni oldindan prognozlash imkoniyatiga ega ekanligi aniqlandi. Modelning umumiy prognoz aniqligi 94 foizni tashkil etdi. Tadqiqot davomida ishlab chiqilgan tizim is gazidan zaharlanish xavfini 12–22 daqiqa oldin aniqlash imkoniyatini namoyish etdi. Bu esa insonlarning xavfsiz hududga chiqishi, ventilyatsiya tizimlarini ishga tushirishi va favqulodda xizmatlarga murojaat qilishi uchun yetarli vaqt yaratadi. Shuningdek, mobil ilova va IoT texnologiyalari bilan integratsiyalashgan ogohlantirish tizimi xavf haqida tezkor ma'lumot yetkazish imkoniyatini yaratdi. Natijalar sun'iy intellekt asosidagi monitoring tizimlari aholi xavfsizligini oshirish va favqulodda vaziyatlarning oldini olishda muhim ahamiyatga ega ekanligini ko'rsatdi. Kelgusida tizimni aqlli uy (Smart Home), aqlli shahar (Smart City) va raqamli egizak (Digital Twin) texnologiyalari bilan integratsiyalash orqali yanada takomillashtirish mumkin.

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ASSESSMENT AND MANAGEMENT OF ACCIDENT RISKS IN RESERVOIRS AND DAMS

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Abstract

This article analyzes modern approaches to assessing and managing potential accident risks in reservoirs and dams. Threats related to the technical condition of dams, hydrological factors, seismic hazards, and human factors are examined. In addition, effective methods of risk management for hydraulic structures are discussed based on the experiences of the Netherlands, Norway, Switzerland, China, and the United States. The research findings demonstrate that digital monitoring, geoinformation technologies, and artificial intelligence-based control systems play a significant role in ensuring the safety of reservoirs and dams.

Keywords

reservoir, dam, hydraulic structures, accident risk, monitoring, risk management, hydrological hazard, emergency situations, hydraulic safety.

SUV OMBORLARI VA TO'G'ONLARDA AVARIYA XAVFINI BAHOLASH HAMDA BOSHQARISH MASALALARI

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Annotatsiya. Mazkur maqolada suv omborlari va to'g'onlarda yuzaga kelishi mumkin bo'lgan avariya xavflarini baholash hamda boshqarishning zamonaviy yondashuvlari tahlil qilingan. To'g'onlarning texnik holati, gidrologik omillar, seysmik xavflar va inson omili bilan bog'liq tahdidlar o'rganilgan. Shuningdek, Niderlandiya, Norvegiya, Shveysariya, Xitoy va AQSh tajribalari asosida gidrotexnika inshootlarida





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xavflarni boshqarishning samarali usullari yoritilgan. Tadqiqot natijalari suv omborlari va to'g'onlar xavfsizligini ta'minlashda raqamli monitoring, geoinformatsion texnologiyalar va sun'iy intellekt asosidagi nazorat tizimlarining muhim ahamiyatga ega ekanligini ko'rsatadi.

Kalit so'zlar: suv ombori, to'g'on, gidrotexnika inshootlari, avariya xavfi, monitoring, xavflarni boshqarish, gidrologik xavf, favqulodda vaziyatlar, gidrotexnika xavfsizligi.

Kirish. Suv omborlari va to'g'onlar mamlakat iqtisodiyotining muhim infratuzilma obyektlari hisoblanadi. Ular suv resurslarini boshqarish, qishloq xo'jaligini sug'orish, gidroenergetika va aholini ichimlik suvi bilan ta'minlashda muhim rol o'ynaydi. Shu bilan birga, ushbu inshootlarda yuzaga keladigan avariylar katta miqyosdagi favqulodda vaziyatlarni keltirib chiqarishi mumkin. To'g'onning buzilishi yoki suv omborining avariya holatiga kelishi natijasida aholi punktlari, sanoat obyektlari va transport infratuzilmasiga jiddiy zarar yetishi mumkin.

So'nggi yillarda iqlim o'zgarishi, kuchli yog'ingarchiliklar, seysmik faollik va gidrotexnika inshootlarining eskirishi xavflarni yanada oshirmoqda. Shu sababli suv omborlari va to'g'onlarda avariya xavfini baholash hamda boshqarish masalalari favqulodda vaziyatlar sohasining dolzarb yo'nalishlaridan biri hisoblanadi. Mazkur tadqiqotning maqsadi suv omborlari va to'g'onlarda yuzaga keladigan avariya xavflarini tahlil qilish hamda ularni boshqarishning zamonaviy usullarini ishlab chiqishdan iborat.

1. Mavzuga oid adabiyotlar tahlili

Gidrotexnika inshootlari xavfsizligini ta'minlash bo'yicha ilmiy tadqiqotlar dunyoning ko'plab davlatlarida olib borilmoqda. ICOLD (International Commission on Large Dams) hisobotlarida qayd etilishicha, dunyo bo'yicha 60 mingdan ortiq yirik to'g'onlar mavjud bo'lib, ularning xavfsizligini ta'minlash davlatlar oldidagi ustuvor vazifalardan biri hisoblanadi. Graham tomonidan olib borilgan tadqiqotlarda to'g'on avariylarining asosiy sabablari sifatida:

konstruktiv nuqsonlar;





gidrologik hisob-kitoblardagi xatolar;
texnik xizmat ko'rsatishning yetarli emasligi;
ekstremal tabiiy hodisalar ko'rsatib o'tilgan. Xu va hamkorlari tomonidan olib borilgan ilmiy izlanishlarda sun'iy intellekt va sensor monitoring tizimlaridan foydalanish to'g'onlar xavfsizligini sezilarli darajada oshirishi ilmiy asoslangan. Yevropa va Shimoliy Amerika mamlakatlarida gidrotexnika inshootlari xavfsizligini baholashda GIS texnologiyalari va raqamli monitoring tizimlari keng qo'llanilmoqda.

2. Tadqiqot metodologiyasi

Tadqiqot davomida tizimli tahlil, qiyosiy tahlil, xavflarni baholash va statistik ma'lumotlarni umumlashtirish usullaridan foydalanildi.

Tadqiqotning axborot bazasini:

ICOLD hisobotlari;

BMT ma'lumotlari;

gidrotexnika xavfsizligiga oid ilmiy maqolalar;

xorijiy davlatlarning amaliy tajribasi;

favqulodda vaziyatlar bo'yicha xalqaro hisobotlar tashkil etdi.

Tahlil quyidagi yo'nalishlarda olib borildi:

avariya xavf omillari;

monitoring tizimlari;

xavflarni boshqarish mexanizmlari;

xorijiy tajriba;

O'zbekiston sharoitida qo'llash imkoniyatlari.

3. To'g'on va suv omborlarida avariya xavfini keltirib chiqaruvchi omillar

Suv omborlari va to'g'onlarda yuzaga keladigan avariylar ko'plab tabiiy va texnogen omillar ta'sirida sodir bo'ladi. Ushbu omillarni o'z vaqtida aniqlash va baholash xavfsizlikni ta'minlashning asosiy shartlaridan biri hisoblanadi.

Gidrologik omillar. Kuchli yog'ingarchiliklar, qorlarning tez erishi va suv





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oqimlarining keskin ortishi suv omborlari va to'g'onlarga katta yuklama beradi.

Bunday holatlar:

suv sathining me'yordan oshishi;

to'g'on tanasining yuvilishi;

favqulodda suv tashlash inshootlarining ortiqcha yuklanishi

kabi xavfli vaziyatlarni yuzaga keltiradi.

Seysmik omillar. Seysmik faol hududlarda joylashgan gidrotexnika inshootlari zilzila ta'siriga uchrashi mumkin.

Zilzila natijasida:

to'g'on tanasida yoriqlar hosil bo'lishi;

beton konstruksiyalarning shikastlanishi;

suv sizib chiqishining kuchayishi kuzatiladi.

Texnik eskirish. Ko'plab suv omborlari va to'g'onlar o'nlab yillar avval qurilgan bo'lib, ularning konstruktiv elementlari vaqt o'tishi bilan eskiradi.

Texnik eskirish:

metall qismlarning korroziyasi;

beton konstruksiyalarning yemirilishi;

drenaj tizimlarining ishdan chiqishi orqali xavf darajasini oshiradi.

Inson omili. Avariya xavfining muhim sabablaridan biri inson omili hisoblanadi. Bunga:

ekspluatatsiya qoidalarining buzilishi;

monitoringning yetarli darajada olib borilmasligi;

noto'g'ri boshqaruv qarorlari;

texnik nazoratning sustligi kiradi.

Iqlim o'zgarishi

Global iqlim o'zgarishi natijasida ekstremal yog'ingarchiliklar va suv oqimlarining keskin ortishi kuzatilmoqda.





Bu esa mavjud gidrotexnika inshootlari loyihalashtirilgan parametrlarning o'zgarishiga olib kelmoqda.

4. Avariya xavfini baholashning zamonaviy usullari

Risk-tahlil.usuli Risk-tahlil usuli avariya ehtimoli va uning oqibatlarini baholashga asoslanadi. Mazkur usul yordamida: xavf manbalari aniqlanadi ehtimoliy zararlar hisoblanadi; ustuvor xavf zonalari belgilanadi. GIS texnologiyalari Geoinformatsion tizimlar yordamida:

suv bosish zonalari xaritalashtiriladi;

xavfli hududlar aniqlanadi;

favqulodda vaziyat ssenariylari modellashtiriladi.

Masofadan zondlash texnologiyalari

Sun'iy yo'ldosh ma'lumotlari va dronlardan foydalanish orqali:

to'g'onlar holati monitoring qilinadi;

deformatsiyalar aniqlanadi;

suv omborlari parametrlari nazorat qilinadi.

Sensor monitoring tizimlari

Zamonaviy gidrotexnika inshootlarida quyidagi sensorlar qo'llaniladi:

deformatsiya sensorlari;

bosim sensorlari;

suv sathi datchiklari;

seysmik kuzatuv qurilmalari.

Ular real vaqt rejimida ma'lumotlarni uzatib boradi.

Sun'iy intellekt asosidagi tahlil

Sun'iy intellekt algoritmlari katta hajmdagi monitoring ma'lumotlarini qayta ishlash orqali:

avariya xavfini prognozlaydi;

xavfli tendensiyalarni aniqlaydi;





ogohlantirishlar ishlab chiqadi.

5. Xorijiy tajriba

Niderlandiya tajribasi. Niderlandiya suv resurslarini boshqarish bo'yicha dunyodagi yetakchi davlatlardan biridir.

Mamlakat hududining katta qismi dengiz sathidan pastda joylashganligi sababli:

raqamli monitoring tizimlari;

aqlli gidrotexnika inshootlari;

GIS asosidagi xavf xaritalari keng qo'llaniladi.

Norvegiya tajribasi. Norvegiyada ko'plab gidroelektr stansiyalari va suv omborlari mavjud.

Mamlakatda:

masofaviy monitoring;

avtomatlashtirilgan nazorat tizimlari;

sun'iy yo'ldosh kuzatuvlari yordamida gidrotexnika inshootlari nazorat qilinadi.

Shveysariya tajribasi

Shveysariya tog'li hududlarda joylashgan yirik suv omborlari xavfsizligini ta'minlash bo'yicha katta tajribaga ega.

Mamlakatda:

geodezik monitoring;

GPS nazorat tizimlari;

seysmik kuzatuv tarmoqlari to'g'onlar xavfsizligini ta'minlashda muhim rol o'ynaydi.

Xitoy tajribasi

Xitoy dunyodagi eng yirik gidrotexnika inshootlaridan biri bo'lgan "Three Gorges Dam" to'g'oniga ega.

Mazkur obyekt:

sun'iy intellekt;

Big Data texnologiyalari;





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minglab sensorlar yordamida nazorat qilinadi.

Natijada xavfli holatlar erta aniqlanadi.

AQSh tajribasi AQShda Federal Emergency Management Agency (FEMA) va United States Army Corps of Engineers to'g'onlar xavfsizligini monitoring qilish bo'yicha keng ko'lamli dasturlarni amalga oshirmoqda.

Mamlakatda:

Dam Safety Program;

GIS monitoring;

sun'iy yo'ldosh kuzatuvlari;

favqulodda vaziyatlar ssenariylari keng qo'llaniladi.

6. Taklif etilayotgan xavfsizlikni boshqarish modeli

Tadqiqot natijalari asosida suv omborlari va to'g'onlarda xavfsizlikni boshqarishning besh bosqichli modeli taklif etiladi.

1-bosqich. Monitoring

Ma'lumotlar quyidagi manbalardan olinadi:

sensorlar;

dronlar;

meteorologik stansiyalar;

sun'iy yo'ldoshlar.

2-bosqich. Ma'lumotlarni integratsiyalash

Barcha ma'lumotlar yagona raqamli platformaga jamlanadi.

3-bosqich. Xavfni baholash

GIS va sun'iy intellekt texnologiyalari yordamida:

xavf darajasi;

avariya ehtimoli;

ehtimoliy zararlar hisoblab chiqiladi.

4-bosqich. Qaror qabul qilish





Mutaxassislar tomonidan xavfni kamaytirish bo'yicha zarur choralar belgilanadi.

5-bosqich. Favqulodda vaziyatlarga tayyorgarlik

Aholini ogohlantirish, evakuatsiya rejalarini ishlab chiqish va qutqaruv xizmatlarini tayyor holatda saqlash ishlari amalga oshiriladi.

Taklif etilgan model suv omborlari va to'g'onlarda avariya xavfini kamaytirish hamda Favqulodda vaziyatlar vazirligi faoliyati samaradorligini oshirishga xizmat qiladi.

7. Tadqiqot natijalari

Tadqiqot davomida gidrotexnika inshootlari xavfsizligini ta'minlash bo'yicha xalqaro tajriba va zamonaviy texnologiyalar tahlil qilindi. Olingan natijalar suv omborlari va to'g'onlarda avariya xavfini baholash hamda boshqarishda kompleks yondashuvdan foydalanish zarurligini ko'rsatdi.

Tahlillar natijasida quyidagi xulosalarga kelindi:

zamonaviy monitoring tizimlari avariya xavfini erta aniqlash imkonini beradi;

GIS texnologiyalari xavfli hududlarni aniq xaritalashtirishga yordam beradi;

sun'iy intellekt asosidagi tizimlar xavfli tendensiyalarni oldindan prognozlaydi;

sensor monitoringi real vaqt rejimida nazoratni ta'minlaydi;

favqulodda vaziyatlarga tayyorgarlik darajasi oshirilganda avariya oqibatlari sezilarli kamayadi.

Shuningdek, xorijiy davlatlar tajribasi raqamli texnologiyalar va avtomatlashtirilgan nazorat tizimlari to'g'onlar xavfsizligini ta'minlashda muhim ahamiyat kasb etishini tasdiqladi.

1-jadval. To'g'onlar xavfsizligini baholashda an'anaviy va zamonaviy usullarning qiyosiy tahlili

Ko'rsatkich	An'anaviy usullar Zamonaviy texnologiyalar	
Monitoring davriyligi	Davriy	Uzluksiz
Ma'lumot olish tezligi	Past	Yuqori





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Ko'rsatkich	An'anaviy usullar	Zamonaviy texnologiyalar
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Prognozlash imkoniyati	Cheklangan	Yuqori
Xavfni baholash aniqligi	O'rta	Yuqori
Favqulodda ogohlantirish	Qisman	Avtomatlashtirilgan
Qaror qabul qilish	Qo'lda	Raqamlashtirilgan

Jadval ma'lumotlari zamonaviy texnologiyalar gidrotexnika inshootlari xavfsizligini ta'minlashda an'anaviy usullarga nisbatan ancha samarali ekanligini ko'rsatadi.

8. Taklif va tavsiyalar

Tadqiqot natijalari asosida quyidagi taklif va tavsiyalar ishlab chiqildi.

1. Raqamli monitoring tizimlarini joriy etish

Yirik suv omborlari va to'g'onlarda avtomatlashtirilgan monitoring tizimlarini joriy etish zarur.

2. GIS texnologiyalaridan foydalanishni kengaytirish

Xavf xaritalarini yaratish va avariya ssenariylarini modellashtirish uchun GIS texnologiyalaridan keng foydalanish tavsiya etiladi.

3. Sun'iy intellekt asosidagi prognozlash tizimlarini yaratish

Monitoring ma'lumotlarini qayta ishlash va xavfli holatlarni prognozlash uchun sun'iy intellekt algoritmlarini joriy etish maqsadga muvofiqdir.

4. Dron monitoringini rivojlantirish

Gidrotexnika inshootlarining texnik holatini baholashda uchuvchisiz uchish apparatlaridan foydalanish ko'lamini kengaytirish lozim.

Xulosa

Suv omborlari va to'g'onlar strategik ahamiyatga ega obyektlar bo'lib, ularning xavfsizligini ta'minlash davlat xavfsizligi va aholi farovonligining muhim omillaridan biridir. Tadqiqot natijalari shuni ko'rsatdiki, gidrotexnika inshootlarida yuzaga kelishi mumkin bo'lgan avariya xavflarini kamaytirishda zamonaviy raqamli texnologiyalar, geoinformatsion tizimlar, masofadan zondlash vositalari va sun'iy intellekt asosidagi





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monitoring tizimlari katta ahamiyatga ega. Niderlandiya, Norvegiya, Shveysariya, Xitoy va AQSh tajribasi gidrotexnika inshootlari xavfsizligini ta'minlashda ilg'or texnologiyalarning samaradorligini tasdiqlaydi. O'zbekiston Respublikasida ham suv omborlari va to'g'onlarda xavfsizlikni ta'minlash bo'yicha raqamli monitoring tizimlarini joriy etish, GIS texnologiyalaridan foydalanish va sun'iy intellekt asosidagi prognozlash tizimlarini rivojlantirish favqulodda vaziyatlar xavfini sezilarli darajada kamaytirishga xizmat qiladi.

Foydalanilgan adabiyotlar

1. O'zbekiston Respublikasining "Gidrotexnika inshootlarining xavfsizligi to'g'risida"gi Qonuni.
2. O'zbekiston Respublikasining Suv kodeksi.
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An Algorithm for Evaluating the Sustainability of Supply Chain Structure

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Abstract

This paper analyzes the issues of assessing the sustainability of supply chain structures and proposes an algorithm for its evaluation. The study examines internal and external factors affecting supply chain sustainability, risks, disruptions in logistics processes, and their impact on overall system performance. Sustainability assessment criteria are developed, and based on these criteria, a decision-support algorithm is formulated. The proposed algorithm enables the coordination of activities among supply chain participants, early identification of risks, reduction of logistics costs, efficient utilization of resources, and improvement of service quality and reliability. The research findings have significant scientific and practical importance for enhancing logistics and supply chain management systems, as well as for implementing intelligent transportation systems and digital technologies in practice.

Keywords:

supply chain, sustainability, assessment algorithm, logistics, risk management, supply chain management, digital technologies, intelligent transportation systems, efficiency, decision-making.

ЕТКАЗИБ БЕРИШЛАР ЗАНЖИРИ ТУЗИЛМАСИНИНГ БАРҚАРОРЛИГИНИ БАҲОЛАШ АЛГОРИТМИ

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Тошкент давлат транспорт университети магистранти

Аннотация. Ушбу ишда етказиб беришлар занжири тузилмасининг барқарорлигини баҳолаш масалалари таҳлил қилинган ҳамда уни аниқлашга қаратилган алгоритм таклиф этилган. Тадқиқотда етказиб беришлар занжирининг барқарорлигига таъсир этувчи ички ва ташқи омиллар, хавф-хатарлар, логистика жараёнларидаги узилишлар ҳамда уларнинг тизим самарадорлигига таъсири ўрганилган. Барқарорликни баҳолаш мезонлари ишлаб чиқилиб, улар асосида қарор қабул қилишни қўллаб-қувватловчи алгоритм шакллантирилган.

Таклиф этилган алгоритм етказиб беришлар занжири иштирокчилари фаолиятини мувофиқлаштириш, хавфларни олдиндан аниқлаш, логистика харажатларини камайтириш, ресурслардан самарали фойдаланиш ва хизмат кўрсатиш сифати ҳамда ишончлилигини ошириш имконини беради. Тадқиқот натижалари логистика ва таъминот занжирларини бошқариш тизимларини такомиллаштиришда, шунингдек, интеллектуал транспорт тизимлари ва рақамли технологияларни амалиётга татбиқ этишда илмий-амалий аҳамиятга эга.

Калит сўзлар: етказиб беришлар занжири, барқарорлик, баҳолаш алгоритми, логистика, хавф-хатарларни бошқариш, таъминот занжири, рақамли технологиялар, интеллектуал транспорт тизимлари, самарадорлик, қарор қабул қилиш.

Кириш. Ўзбекистон иқтисодиётнинг ривожланиши кўп жиҳатдан транспорт тизими, хусусан автомобиль транспорти билан чамбарчас боғлиқ.

Автомобиль транспортнинг мавқеи ва ривожланиш кўлами, транспорт хизматлари даражаси билан тавсифланади. Шунинг учун ҳам, логистика ва унга тегишли бўлган тамойилларга, унинг назарияси, методологияси, технологиялари ва жараёнлари тўғрисидаги билимларга бўлган чанқоқлик сезиларли даражада ўсиб бормоқда.

Тадқиқотни амалга ошириш учун қуйидаги бошланғич маълумотларда





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етказиб беришлар занжирининг тузилмавий барқарорлигини баҳолаш масаласини кўриб чиқамиз. Тадқиқот 4 та босқични ўз ичига олади. Тадқиқот босқичларининг r_i нисбий муҳимлик коэффициентлари мос равишда 0,2; 0,34; 0,24; 0,22 га тенг. Ҳар бир босқич учун ижрочилар аниқланган: 1-А; 2-В; 3-С; 4-Д.

Етказиб беришлар занжирининг олинган тузилмасини таҳлил қилиш ва унинг ички боғланишини, шакллантирилган тузилманинг “муустаҳкамлигини” консолидация коэффициентини қўллаш асосида баҳолаш зарур. Тузилманинг боғланиш даражасининг уч босқичли градациясини – айнан эса, паст, ўртача ва юқори боғланиш даражасини қабул қиламиз. Консолидация коэффициентининг чегара қийматлари сифатида $\kappa_1 = 0,3$ ва $\kappa_2 = 0,6$ қийматларни қабул қиламиз. Ҳар бир “мувофиқлаштирувчи – ижрочи” жуфтлигида томонларнинг ўзаро манфаатдорлигини аниқлаймиз. Ҳисоблашларни формулалар бўйича бажарамиз, натижаларни 1-жадвалда келтирамиз.

1-жадвал

“Мувофиқлаштирувчи – ижрочи” жуфтлигида ўзаро манфаатдорликни аниқлаш

Манфаатдорликни баҳолаш	Ижрочилар			
	А	В	С	Д
Мувофиқлаштирувчининг ижрочилардан манфаатдорлиги (U_i)	0,95	0,98	0,99	0,98
Ижрочининг лойиҳадан манфаатдорлиги (Z_i)	0,96	0,8	0,75	0,75
“Мувофиқлаштирувчи- ижрочи” жуфтлигида ўзаро манфаатдорликни баҳолаш (U_{0i})	0,95	0,8	0,75	0,75





Иштирокчиларнинг манфаатдорлигининг интеграл кўрсаткичини (консолидация коэффиценти) аниқлаш учун “япроқ” диаграммасини куриш зарур бўлади. Бундай диаграммани куриш учун маълумотлар 17.14 жадвалда келтирилган. Лойиҳанинг бажариладиган босқичининг $r_i^{\text{нисбий}}$ нисбий муҳимлигини аниқлаш қуйидагича амалга оширилади. r_i^{max} максимал муҳимлак даражасига эга бўлган босқич учун $r_i^{\text{нисбий}} = 1$ бўлади. Тадқиқотнинг қолган босқичлари учун $r_i^{\text{нисбий}}$ кўрсаткич қуйидаги қоида бўйича аниқланади:

$$r_i^{\text{нисбий}} = r_i / r_i^{\text{max}} \quad (1)$$

Шерикларнинг нисбий ўзаро манфаатдорлиги $U_{0i}^{\text{нисбий}}$ қуйидаги формула бўйича аниқланади:

$$U_{0i}^{\text{нисбий}} = r_i^{\text{нисбий}} * U_{0i} \quad (2)$$

2- жадвал

Шерикларнинг ўзаро манфаатдорлигини аниқлаш

Кўрсаткичлар	Ижрочилар			
	А	В	С	Д
1.Лойиҳанинг ижрочи томонидан бажариладиган босқичининг муҳимлиги (r_i)	0,2	0,34	0,24	0,22
2.Мувофиқлаштирувчи ва ижрочининг ўзаро манфаатдорлиги (U_{0i})	0,95	0,8	0,75	0,75
3.Лойиҳанинг бажариладиган босқичининг нисбий муҳимлиги ($r_i^{\text{нисбий}}$)	0,59	1	0,71	0,65
4.Нисбий ўзаро	0,56	0,8	0,53	0,49





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манфаатдорлик ($u_{oi}^{\text{нисбий}}$)				
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Кўриниб турибдики, $K_{\text{конс}} > K_2$, яъни қабул қилинган фаразларда шерикларнинг ўзаро манфаатдорлик даражасини юқори деб баҳолаш мумкин. Виртуал корхонанинг тузилмаси, мувофиқлаштирувчининг баҳолашига кўра – етарлича барқарор, лойиҳанинг узилиш хавфи унчалик катта эмас ва етказиб беришлар занжири тузилмасининг таҳлил қилинаётган вариантыни кўпроқ афзал деб ҳисоблаш мумкин.

Буюртманинг суқилиб кириш нуқтасини аниқлаш моделида буюртманинг суқилиб кириш нуқтасининг жойлашув жойини аниқлаш кўплаб омилларга боғлиқ бўлади ва турли тармоқлар учун фарқ қилади. Биз томонимиздан бешта тармоқ – авиасозлик, автомобилсозлик, электротехника, истеъмол товарлари ва фармацевтика тармоқлари учун буюртманинг суқилиб кириш нуқтасининг жойлашув жойини танлаш бўйича амалий тавсияларни бериш имконини берувчи тадқиқотлар ўтказилган.

Бунда омилларнинг ҳар бирига 0 дан 1 гача бўлган диапазонда қиймат берилган (иловага қаралсин). Қийматлар 0 дан 1 гача тоифаланган ($0 =$ “муҳим эмас”; $1 =$ “жуда муҳим”).

3-жадвал

Буюртманинг суқилиб кириш нуқтасининг жойлашув жойи учун харажатларнинг турларининг муҳимлиги

Харажатлар нинг турлари	Ави а созл ик	Автомо бил созлик	Элек тро техн ика	Истеъ мол товарлари	Фар ма цевт ика
Сақлаш	0,2- 0,4	0,4-0,6	0,6- 0,7	0,9-1,0	0,9- 1,0





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Модуллили к	0,9- 1,0	0,9-1,0	0,6- 0,7	0,2-0,4	0,2- 0,4
Ахборот тизимлари	0,2- 0,4	0,6-0,7	0,9- 1,0	0,3-0,5	0,3- 0,5
Бутловчила рни тезда олиш	0,9- 1,0	0,9-1,0	0,6- 0,7	0,3-0,5	0,2- 0,4

Мазкур таҳлил турли тармоқлар учун буюртманинг суқилиб кириш нуқтасининг жойлашув жойини аниқлашда биринчи навбатда ҳисобга олиш зарур бўладиган харажатларнинг турлари бўйича тавсияларни шакллантириш имконини берган.

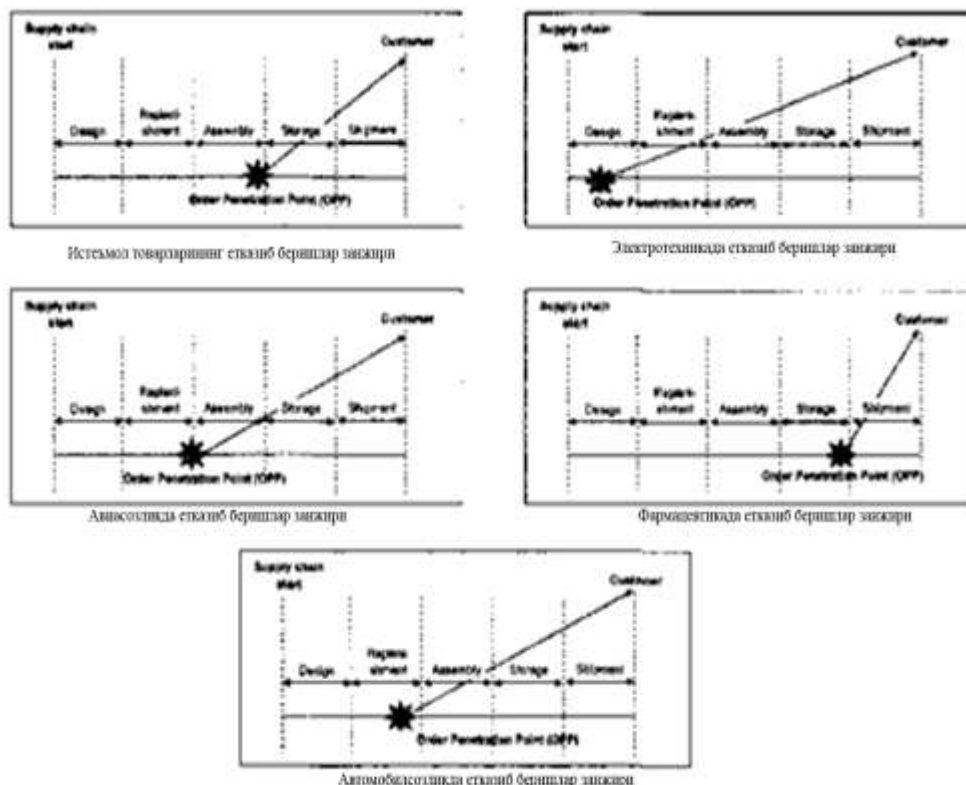
3-жадвалнинг маълумотлари асосида буюртманинг суқилиб кириш нуқтасининг жойлашув жойи бўйича тавсиялар шакллантирилган.

Авваламбор шуни қайд қилиш лозимки, етказиб беришлар занжирининг буюртманинг суқилиб кириш нуқтасидан бошланадиган мослашувчан қисми қуйидагилар ёрдамида қурилиши мумкин:

1. Етказиб беришлар занжирига *маълум бир ошиқчаликни киритиш*, масалан, қўшимча заҳиралар, заҳираларни қўшимча сақлаш жойларини киритиш, модулларни турли комбинацияларга қайишқоқ қайта компановкалаш имконияти билан маҳсулотларнинг модуллилигини максималлаштириш.

2. Кенгайтирилган ахборот мувофиқлаштириши асосида (интернет-технологиялар ва виртуал корхоналар услубиятидан фойдаланиш билан) етказиб беришлар занжирини *тузилмавий-функционал мослаштириш* (масалан, зарурий бутловчиларни тезда олиш учун янги етказиб берувчиларни жалб қилиш).





1-расм. Турли тармоқлар учун буюртманинг суқилиб кириш нуқтасининг жойлашув жойи

Ушбу натижалар қуйидаги таҳлил қилиш тамойилини қўллаш билан имитацион моделлаштириш асосида олинган. Мижоз буюртма ёки талабнома берган тақдирда маҳсулот оғбордан етказиб берилиши мумкин - траектория α (3.8 расм) – ёки мижознинг талабларига кўра индивидуаллаштирилиши мумкин (траектория β). Буюртманинг суқилиб кириш нуқтасининг жойлашув жойи технологик ва иқтисодий мақсадлар ва чеклашлардан келиб чиқиш билан аниқланади, биз томонимиздан буюртманинг суқилиб кириш нуқтасининг жойлашув жойини етказиб беришлар занжирининг иккита стратегияси – етказиб беришлар занжирида мослашувчан қисмнинг борлиги ёки йўқлигининг иқтисодий ва молиявий кўрсаткичларини таққослашдан келиб чиқиш билан аниқлаш таклиф қилинган (1-расм). Кўриб чиқишга қуйидаги параметрлар киритилади:

• D = буюртманинг суқилиб кириш нуқтасининг жойлашув жойининг





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самарадорлигини тавсифлайдиган индекс,

• P = мослашувчан қисмга эга бўлмаган етказиб беришлар занжирининг даромадлилиги,

• P_a = мослашувчан қисмга эга бўлган етказиб беришлар занжирининг даромадлилиги,

• C = мослашувчан қисмга эга бўлмаган етказиб беришлар занжирининг харажатлари,

• C_y^a = мослашувчан қисмга эга бўлган етказиб беришлар занжирининг буюртманинг суқилиб кириш нуктасидан чапдаги участкасидаги харажатлар,

• C_d^a = мослашувчан қисмга эга бўлган етказиб беришлар занжирининг буюртманинг суқилиб кириш нуктасидан ўнгдаги участкасидаги харажатлар,

• P = мослашувчан қисмга эга бўлмаган етказиб беришлар занжирида бажармаганлик учун жарималар,

• P^a = мослашувчан қисмга эга бўлган етказиб беришлар занжирида бажармаганлик учун жарималар,

• L = мослашувчан қисмга эга бўлмаган етказиб беришлар занжирида мижозларнинг бажариш учун қабул қилинмаган талабномаларидан йўқотишлар,

• L^a = мослашувчан қисмга эга бўлган етказиб беришлар занжирида мижозларнинг бажариш учун қабул қилинмаган талабномаларидан йўқотишлар,

• K_ϕ = мослашувчан қисм ҳисбига етказиб беришлар занжирининг қайишқоқлиги ошганда сотишлар ҳажмининг потенциал ортишини ҳисобга оловчи коррекциялаш коэффиценти,

• m = вақт даврлари.

Етказиб беришлар занжирининг (m_0 ; T) цикли давомида буюртманинг суқилиб кириш нуктасининг турли жойлашиш жойлари тадқиқ қилинади ва энг яхши нукта танланади, яъни $D > 1$ индекс (3) формула бўйича максимал қийматни қабул қиладиган нукта танланади:





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$$Д = \left\{ \frac{R_a - (C_u^a + C_d^a + P^a + L^a)}{R - (C + P + L)} \right\} \quad (3)$$

Ушбу детерминантланган таҳлилий формула буюртманинг суқилиб кириш нуқтасининг жойлашиш жойини ҳисоблашда фойдаланиладиган маълумотларнинг амалий характери туфайли таклиф қилинган. Буюртманинг суқилиб кириш нуқтасини жойлаштириш бўйича ечим стратегик характерга эга бўлади. Бундай ечимларда башоратлаш даврининг узоклиги туфайли эҳтимолли моделлардан амалда фойдаланилмайди. (3) формула учун ўтган даврларнинг натижалари ва экспертларнинг фикрлари бошланғич маълумотлар ҳисобланади.

Якунда турли омилларнинг буюртманинг суқилиб кириш нуқтасининг жойлашиш жойига таъсирини таҳлил қилиш натижаларини келтирамыз. Маълумотлар турли етказиб беришлар занжирларини таҳлил қилиш ва интервьюлар олиш асосида олинган.

4-жадвал

Буюртманинг суқилиб кириш нуқтасига таъсир кўрсатувчи омиллар

Омил	Авиасоз- лик	Автомо- билсозлик	Электро- техника	Истеъмол товарлар и	Фарма- цевтика
Маҳсулотнинг мумкин бўлган вариантлари- нинг сони	0,9-1,0	0,9-1,0	0,7-1,0	0,3-0,5	0,1-0,2
Нима индивидуал- лаштирилади?	маҳсулот	маҳсулот	маҳсулот	маҳсулот, партияни нг ўлчами	партия- нинг ўлчами, ўрам
Маҳсулотнинг	0,7-0,8	0,5-0,6	0,7-0,8	0,2-0,4	0,1-0,2





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қанча қисмини технологик индивидуалаш- тириш мумкин?					
Махсулотнинг қанча қисмини технологик модуллаш -мумкин?	0,6-0,8	0,6-0,8	0,5-0,7	0,4-0,8	0,8-0,9
Махсулотнинг нархи	0,9-1,0	0,7-0,9	0,5-0,7	0,4-0,8	0,8-0,9
Тармоқтаги рақобат вазияти	0,1-0,2	0,2-0,3	0,3-0,5	0,6-1,0	0,2-0,4
Етказиб беришлар занжирида буюртмани бажариш цикли	0,9-1,0	0,6-0,8	0,3-0,5	0,1-0,3	0,1-0,3
Етказиб беришлар занжирида махсулотни индивидуал лаштириш цикли	0,8-1,0	0,4-0,6	0,2-0,3	0,3-0,5	0,3-0,5
Стратегик заҳира қаерда сақланади?	ишлаб чиқаришда	ишлаб чиқа- ришда	ишлаб чиқаришда омборда	омборда	омборда
Махсулотга ким буюртма беради?	ташкилот	индиви- дуал истеъмол-	индиви- дуал истеъмол-	улгуржи савдо, чакана	улгуржи савдо, чакана





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		чи, улгуржи савдо, чакана савдо	чи, улгуржи савдо, чакана савдо	савдо	савдо
Маҳсулотни индивидуал- лаштиришга ким буюртма беради?	ташкилот	Индиви- дуал истеъ- молчи	Индиви- дуал истеъ- молчи	улгуржи савдо, чакана савдо	улгуржи савдо, чакана савдо
Ким охирги мижоз ҳисобланади?	ташкилот	индивидуал истеъмолчи	индивидуал истеъмолчи	индивиду ал истеъмол чи	ташкилот , индиви- дуал истеъ- молчи
Мижозларнинг сони	0,1-0,2	0,2-0,3	0,4-0,6	0,5-0,7	0,4-0,6
Мижозлар билан қандай шартнома лардан фойдаланилади?	узоқ муддатли, партиялар	узоқ муддатли, партиялар, алоҳида буюртмалар	ўрта муддатли, партиялар, алоҳида буюртмала р	ўрта муддатли , партияла р	ўрта муддатли , партияла р
Нечта муқобил етказиб берувчилар мавжуд?	0,5-0,7	0,5-0,7	0,4-0,6	0,2-0,3	0,1-0,2
Етказиб берувчилар ўртасида стратегик альянслар бўлиши мумкинлиги	0,9-1,0	0,9-1,0	0,7-0,9	0,4-0,6	0,9-1,0





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(3) формула асосида турли тармоқларнинг алоҳида корхоналари учун Д индекснинг қуйидаги қийматлари олинган:

- > Авиасозлик - 2,3 87
- > Автомобилсозлик -12,1
- > Электротехника-1,2474
- > Истеъмол товарлари - 1,0
- > Фармацевтика- 1,4529

Хулоса. Етказиб беришлар занжири тузилмасининг барқарорлигини баҳолаш алгоритмини ишлаб чиқиш ва амалиётга жорий этиш логистика тизимларининг самарадорлиги ҳамда ишончлилигини оширишда муҳим аҳамиятга эга. Тадқиқот давомида етказиб беришлар занжирига таъсир этувчи асосий омиллар таҳлил қилиниб, уларнинг барқарорликка таъсири баҳоланди. Шунингдек, хавф-хатарларни аниқлаш, уларнинг эҳтимолий оқибатларини баҳолаш ҳамда қарор қабул қилиш жараёнини такомиллаштиришга хизмат қилувчи баҳолаш алгоритми шакллантирилди.

> Таклиф этилган алгоритм етказиб беришлар занжири иштирокчилари ўртасидаги ҳамкорликни мустаҳкамлаш, ресурслардан оқилона фойдаланиш, логистика харажатларини камайтириш ва узилишлар хавфини минималлаштириш имконини беради. Алгоритм ёрдамида занжирнинг заиф бўғинларини ўз вақтида аниқлаш, муқобил етказиб бериш йўналишларини шакллантириш ҳамда ташқи ва ички хавфларга нисбатан тизимнинг мослашувчанлигини ошириш мумкин.

> Умуман олганда, етказиб беришлар занжири тузилмасининг барқарорлигини баҳолаш алгоритмини қўллаш логистика жараёнларининг узлуксизлигини таъминлаш, хизмат кўрсатиш сифати ва рақобатбардошликни оширишга хизмат қилади. Мазкур ёндашувни рақамли технологиялар, сунъий интеллект ва интеллектуал транспорт тизимлари билан интеграция қилиш келгусида янада юқори самарадорликка эришиш имконини яратади.





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THE CONCEPT OF EDUCATIONAL ROBOTICS AND ITS PEDAGOGICAL ESSENCE

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Abstract

The article analyzes the concept of educational robotics, its pedagogical essence, and the purpose of using robotics in preschool education.

Keywords

robotics, preschool education, digital technology, training, design, research, innovative education.

TA'LIMIY ROBOTOTEXNIKA TUSHUNCHASI VA UNING PEDAGOGIK MOHIYATI

Axmedova Gulrux Rustam qizi

Ajiniyoz nomidagi Nukus davlat pedagogika institute Maktabgacha va
boshlang'ich ta'lim fakulteti 2-kurs talabasi

Annotatsiya. Maqolada ta'limiy robototexnika tushunchasi, uning pedagogik mohiyati va maktabgacha ta'limda robototexnikadan foydalanish maqsadi tahlil qilingan.

Kalit so'zlar: robototexnika, maktabgacha ta'lim, raqamli texnologiya, mashg'ulot, konstruktorlik, tadqiqotchilik, innovatsion ta'lim.

Аннотация. В статье анализируется понятие образовательной робототехники, ее педагогическая сущность и цель использования робототехники в дошкольном образовании.

Ключевые слова: робототехника, дошкольное образование, цифровые технологии, обучение, проектирование, исследования, инновационное образование.





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Bugungi kunda dunyo ta'lim tizimida raqamli texnologiyalarni ta'lim jarayoniga joriy etish, bolalarda XXI asr ko'nikmalarini shakllantirish hamda innovatsion ta'lim muhitini yaratish ustuvor yo'nalishlardan biri hisoblanadi. Shu nuqtai nazardan ta'limiy robototexnika maktabgacha ta'lim tizimida keng qo'llanila boshlagan zamonaviy pedagogik yo'nalish sifatida alohida ahamiyat kasb etmoqda. Ta'limiy robototexnika - bu bolalarning yosh va individual xususiyatlarini hisobga olgan holda konstruktorlik, modellashtirish, oddiy dasturlash elementlari hamda muammoli vaziyatlarni hal etishga asoslangan ta'lim faoliyatidir. Mazkur faoliyat davomida bola nafaqat tayyor modelni yig'ishni o'rganadi, balki kuzatish, tahlil qilish, taqqoslash, sabab-oqibat bog'lanishlarini aniqlash, mustaqil qaror qabul qilish va ijodiy fikrlash ko'nikmalarini ham rivojlantiradi.

Maktabgacha ta'limda robototexnikadan foydalanishning asosiy maqsadi bolalarni texnik mutaxassis sifatida tayyorlash emas, balki ularning bilish faolligini oshirish, ijodiy salohiyatini rivojlantirish, mantiqiy tafakkurini shakllantirish hamda atrofdagi olamni o'rganishga bo'lgan tabiiy qiziqishini qo'llab-quvvatlashdan iboratdir. Shu sababli robototexnika mashg'ulotlari o'yin, tajriba, konstruktorlik va tadqiqotchilik faoliyatini yagona pedagogik jarayonga birlashtiradi.

Ta'limiy robototexnika STEAM yondashuvining muhim tarkibiy qismi hisoblanadi. Ushbu yondashuv fan (Science), texnologiya (Technology), muhandislik (Engineering), san'at (Arts) va matematika (Mathematics) yo'nalishlarini o'zaro integratsiyalash orqali bolalarning kompleks fikrlashini rivojlantirishga xizmat qiladi. Robototexnika mashg'ulotlarida bolalar konstruktor detallarini yig'ish jarayonida geometrik shakllar, o'lchamlar, muvozanat, harakat, ketma-ketlik va oddiy algoritmlar bilan tanishadilar. Shu bilan birga ular o'z tasavvurlarini amaliy faoliyat orqali namoyon etish imkoniyatiga ega bo'ladilar.

Maktabgacha yoshdagi bolalar uchun robototexnika mashg'ulotlari qiziqarli o'yin shaklida tashkil etilishi muhimdir. Chunki aynan o'yin faoliyati ushbu yosh davrida





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bolaning yetakchi faoliyati hisoblanadi. Mashg'ulotlar davomida bolalar tayyor namunani nusxalash bilan cheklanib qolmay, o'z g'oyalari asosida yangi modellar yaratishga, ularni takomillashtirishga va turli muammolarga yechim topishga intiladilar. Natijada ularda tashabbuskorlik, mustaqillik, hamkorlikda ishlash va o'z fikrini asoslay olish ko'nikmalari rivojlanadi.

Ta'limiy robototexnika tarbiyachining faoliyatiga ham yangi talablarni qo'yadi. Pedagog endilikda faqat bilim beruvchi emas, balki bolalarning izlanish faoliyatini tashkil etuvchi, maslahat beruvchi va yo'naltiruvchi shaxs sifatida namoyon bo'ladi. Tarbiyachi bolalarni tayyor javob bilan ta'minlamasdan, ularni mustaqil fikrlashga, savollar berishga, tajriba o'tkazishga va xulosalar chiqarishga undashi zarur. Aynan shunday pedagogik yondashuv bolalarda barqaror qiziqish va ichki motivatsiyaning shakllanishiga xizmat qiladi.

Maktabgacha yosh bolaning shaxs sifatida shakllanishida eng muhim davrlardan biri hisoblanadi. Aynan ushbu davrda bolada atrof-muhitga nisbatan tabiiy qiziqish, bilishga intilish, yangi narsalarni o'rganishga bo'lgan ehtiyoj va mustaqil faoliyatga moyillik jadal rivojlanadi. Shu sababli maktabgacha ta'lim tashkilotlarida tashkil etiladigan har qanday pedagogik faoliyat bolalarning yosh va individual xususiyatlarini hisobga olgan holda rejalashtirilishi lozim.

Ta'limiy robototexnika mashg'ulotlari bolalarning tabiiy qiziqishidan samarali foydalanish imkonini beradi. Konstruktor detallarini birlashtirish, yangi modellar yaratish, ularning harakatini kuzatish va natijalarni tahlil qilish jarayonida bolalar faol ishtirok etadilar. Bunday faoliyat ularda nafaqat yangi bilimlarni egallash, balki o'z fikrini erkin ifodalash, muammolarni hal qilish va ijodiy yondashuvni namoyon etish ko'nikmalarini ham rivojlantiradi.

Psixologik tadqiqotlar shuni ko'rsatadiki, maktabgacha yoshdagi bolalarda qiziqish ko'proq hissiy taassurotlar va amaliy faoliyat orqali shakllanadi. Agar mashg'ulot bolada hayrat uyg'otsa, unda faol harakat qilish imkoniyati yaratilsa hamda





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muvaffaqiyat hissi yuzaga kelsa, qiziqish barqarorlashadi. Shu sababli robototexnika mashg'ulotlari bolalarni tayyor bilimlarni o'zlashtirishga emas, balki ularni mustaqil izlanishga undaydigan tarzda tashkil etilishi maqsadga muvofiqdir.

Shunday qilib, ta'limiy robototexnika maktabgacha ta'lim tizimida bolalarning intellektual, ijodiy va ijtimoiy rivojlanishini ta'minlovchi samarali pedagogik vosita hisoblanadi. U zamonaviy ta'limning innovatsion yo'nalishlarini amaliyot bilan uyg'unlashtirish, bolalarni faol o'rganishga jalb etish va keyingi ta'lim bosqichlariga puxta tayyorlash imkonini beradi.

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**DEVELOPMENT OF AN INTELLIGENT PREDICTIVE
MAINTENANCE FRAMEWORK FOR INDUSTRIAL EQUIPMENT
USING ARTIFICIAL INTELLIGENCE AND DIGITAL TWIN
TECHNOLOGY**

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Abstract

Vibration-based machine-learning classifiers have become a common substitute for fixed-interval preventive maintenance, yet they remain fundamentally pattern-matching tools: they flag deviations from historical normal behavior without reference to the physical degradation mechanism producing the deviation, which limits both the lead time and the precision of the failure predictions they generate. This study proposes a Digital Twin-Coupled Anomaly-to-Remaining-Useful-Life (DT-ARUL) framework, in which a physics-based digital twin of the monitored equipment generates an expected sensor response under current operating conditions, the residual between this expected response and the measured IoT sensor stream is treated as a physically interpretable degradation signal, and a data-driven correction model maps the accumulated residual trajectory onto a probabilistic remaining-useful-life estimate that is continuously updated through Bayesian filtering as new measurements arrive. A dynamic maintenance-threshold optimization layer subsequently converts this RUL distribution into a maintenance-triggering decision by minimizing the expected total cost of premature replacement against the expected cost of in-service failure. The framework was evaluated on a representative rotating-equipment case (centrifugal pump and induction-motor assembly) instrumented with vibration, temperature, and current sensors, compared against a fixed-interval baseline and a standalone vibration-classifier approach. The proposed framework extended mean prediction lead time from 4.2 to 11.6





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days, reduced the false-alarm rate from 18.4% to 6.3%, and lowered annual maintenance cost by 44% relative to baseline, with a five-year net present value more than double that of the standalone classifier approach.

Keywords

predictive maintenance; digital twin; remaining useful life; Internet of Things; vibration analysis; Bayesian filtering; maintenance cost optimization.

Аннотация

Классификаторы на основе машинного обучения, анализирующие вибрационные сигналы, стали распространённой альтернативой планово-предупредительному обслуживанию с фиксированным интервалом, однако по своей сути они остаются инструментами сопоставления образов: они фиксируют отклонения от исторически нормального поведения оборудования без учёта физического механизма деградации, вызывающего это отклонение, что ограничивает как заблаговременность, так и точность формируемых прогнозов отказа. В настоящем исследовании предложена модель связанного с цифровым двойником преобразования аномалии в остаточный ресурс (Digital Twin-Coupled Anomaly-to-Remaining-Useful-Life, DT-ARUL), в которой физически обоснованный цифровой двойник контролируемого оборудования формирует ожидаемый отклик датчиков при текущих условиях эксплуатации, невязка между этим ожидаемым откликом и измеренным потоком данных IoT-датчиков рассматривается как физически интерпретируемый сигнал деградации, а модель коррекции на основе данных отображает накопленную траекторию невязки на вероятностную оценку остаточного ресурса, непрерывно обновляемую посредством байесовской фильтрации по мере поступления новых измерений. Уровень динамической оптимизации порога технического обслуживания преобразует полученное распределение остаточного ресурса в решение о проведении обслуживания путём минимизации ожидаемых суммарных затрат на





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преждевременную замену относительно ожидаемых затрат на отказ в процессе эксплуатации. Предложенная модель увеличила среднее время упреждающего прогнозирования с 4,2 до 11,6 суток, снизила долю ложных срабатываний с 18,4% до 6,3% и уменьшила годовые затраты на обслуживание на 44% по сравнению с базовым вариантом.

Ключевые слова: *предиктивное обслуживание; цифровой двойник; остаточный ресурс; интернет вещей; вибрационный анализ; байесовская фильтрация; оптимизация затрат на обслуживание.*

Annotatsiya

Tebranish signallariga asoslangan mashinaviy o'rganish klassifikatorlari qat'iy intervalli profilaktik texnik xizmat ko'rsatishning keng tarqalgan muqobiliga aylandi, biroq ular mohiyatan namuna moslashtirish vositalari bo'lib qolmoqda: ular og'ishni keltirib chiqaruvchi fizik degradatsiya mexanizmiga murojaat qilmasdan, tarixiy normal xatti-harakatdan chetlanishlarni qayd etadi, bu esa ular hosil qiladigan nosozlik bashoratlarining ham oldindan aniqlash muddatini, ham aniqligini cheklaydi. Ushbu tadqiqotda Raqamli Egizakka Bog'langan Anomaliyadan Qolgan Foydali Umrda O'tish (DT-ARUL) modeli taklif etiladi, unda nazorat qilinayotgan uskunaning fizikaviy asoslangan raqamli egizagi joriy ishlash sharoitlarida kutilgan sensor javobini shakllantiradi, ushbu kutilgan javob bilan o'lchangan IoT-sensor oqimi o'rtasidagi qoldiq fizik jihatdan talqin qilinadigan degradatsiya signali sifatida ko'rib chiqiladi, ma'lumotlarga asoslangan tuzatish modeli esa to'plangan qoldiq траектория sini yangi o'lchovlar kelib tushishi bilan Bayes filtratsiyasi orqali uzluksiz yangilanadigan ehtimoliy qolgan foydali umr bahosiga aylantiradi. Dinamik texnik xizmat ko'rsatish chegarasini optimallashtirish qatlami olingan qolgan foydali umr taqsimotini muddatidan oldin almashtirish kutilgan xarajatlarini ish jarayonidagi nosozlik kutilgan xarajatlariga nisbatan minimallashtirish orqali texnik xizmat ko'rsatish to'g'risidagi qarorga aylantiradi. Taklif etilgan model o'rtacha oldindan bashorat qilish muddatini 4,2





kundan 11,6 kungacha oshirdi, yolg'on signal darajasini 18,4% dan 6,3% gacha kamaytirdi va yillik texnik xizmat ko'rsatish xarajatlarini boshlang'ich holatga nisbatan 44% ga pasaytirdi.

Kalit so'zlar: bashoratli texnik xizmat ko'rsatish; raqamli egizak; qolgan foydali umr; narsalar interneti; tebranish tahlili; Bayes filtratsiyasi; texnik xizmat ko'rsatish xarajatlarini optimallashtirish.

1. Introduction and Objective

Rotating industrial equipment — pumps, compressors, motors, and gearboxes — accounts for a disproportionate share of unplanned industrial downtime, and the maintenance strategies applied to it have evolved in two largely separate directions. The first, fixed-interval preventive maintenance, replaces or overhauls components on a calendar or run-hour schedule regardless of actual condition, which avoids catastrophic failure at the cost of a substantial number of premature, unnecessary interventions. The second, condition-based maintenance using machine-learning classifiers trained on vibration, temperature, or current signatures, triggers action when the monitored signal departs from a learned normal envelope; this approach reduces unnecessary replacement relative to fixed-interval scheduling, but because the classifier has no explicit model of the underlying physical degradation process, its lead time is limited to whatever interval elapses between the onset of a statistically detectable anomaly and functional failure, and its false-alarm rate remains sensitive to operating-condition changes that a purely data-driven model has not previously encountered. The scientific problem this study addresses is the disconnection between physically grounded degradation modeling and data-driven anomaly detection in current predictive-maintenance practice, and the corresponding absence of a unified architecture that converts a physically interpretable degradation signal into both an early, well-calibrated remaining-useful-life estimate and an economically optimal maintenance-triggering decision. The objective is to design and evaluate the DT-ARUL framework, in which a digital twin's physics-based residual





replaces the raw sensor signal as the primary input to failure prognosis, and to quantify the resulting gains in prediction lead time, estimation accuracy, and maintenance economics against both fixed-interval and standalone classifier practice on a representative rotating-equipment case. The novelty of the proposed contribution consists of three elements: (i) the use of a physics-based digital-twin residual, rather than the raw multi-sensor signal, as the input to the prognosis model, which grounds the anomaly signal in a specific, physically identifiable degradation mode (bearing wear, rotor imbalance, seal degradation) rather than an unlabelled statistical departure; (ii) a Bayesian sequential-updating scheme that treats the remaining-useful-life estimate as a continuously refined probability distribution rather than a point forecast, allowing uncertainty to be explicitly propagated into the maintenance decision; and (iii) a dynamic maintenance-threshold rule derived from an explicit expected-cost minimization rather than a fixed confidence-level trigger, which connects the technical prognosis directly to maintenance economics.

2. Methodology and Analytical Setup

The framework was developed and validated in five stages using a centrifugal pump and induction-motor assembly instrumented with tri-axial vibration accelerometers, bearing-housing temperature sensors, and a three-phase current transducer, sampled at rates appropriate to each signal type and aggregated through an edge-computing gateway. In the first stage, a reduced-order physics-based digital twin of the assembly was constructed, combining a rotor-dynamics model of shaft vibration with a thermal model of bearing heat generation, parameterized from the equipment's design specifications and calibrated against six months of healthy-state operating data. The twin outputs an expected sensor response $\hat{y}(t)$ for the current operating point (speed, load, ambient temperature).

In the second stage, the physically interpretable residual signal was defined for each sensor channel i as





$$r_i(t) = y_i(t) - \hat{y}_i(t),$$

and an aggregate degradation index $D(t)$ was computed as a weighted Mahalanobis distance of the residual vector across channels, normalized against the residual covariance observed during the healthy-state calibration period, so that $D(t)$ rises specifically in response to degradation-consistent deviations rather than to normal operating-condition changes already captured by the twin. In the third stage, a Bayesian sequential-updating model was applied to map the accumulated trajectory of $D(t)$ onto a posterior distribution over remaining useful life, using a stochastic degradation-path model (a Wiener process with drift estimated from historical run-to-failure records of comparable assets) as the prior and updating the drift and diffusion parameters as new degradation-index observations arrive, so that the RUL distribution narrows progressively as more evidence accumulates rather than being fixed at the time of the first detected anomaly.

In the fourth stage, a dynamic maintenance threshold was derived by minimizing the expected total cost function

$$E[C(\tau)] = C_{PM} \cdot P(T_{fail} > \tau) + C_{fail} \cdot P(T_{fail} \leq \tau) + C_{downtime} \cdot E[downtime | decision at \tau],$$

where τ denotes the candidate maintenance-triggering time, C_{PM} the cost of a planned intervention, C_{fail} the cost of an unplanned in-service failure including secondary damage, and the expectation is taken over the current posterior RUL distribution; the optimal τ^* is the value minimizing $E[C(\tau)]$, recomputed at each measurement update rather than fixed in advance. In the fifth stage, three maintenance strategies were compared over a two-year monitoring period on the instrumented assembly and four comparable units at the same facility: (a) the baseline fixed-interval schedule already in use at the site; (b) the existing standard approach, a vibration-only machine-learning classifier trained on the same sensor data without the digital-twin residual or cost-based threshold; and (c) the proposed DT-ARUL framework.





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Parameter	Baseline / Control Model (fixed-interval PM)	Existing Standard Approach (vibration only)	Proposed Integrated (ML classifier ARUL framework) (DT-)
Mean prediction lead time before failure, days	—	4.2	11.6
RUL prediction error (MAE), days	—	5.8	2.1
False alarm rate, %	—	18.4	6.3
Missed-detection rate, %	—	9.7	2.4
Unplanned downtime, hours/year	312	168	74
Mean time between failures (MTBF), hours	1,840	2,610	3,920
Annual maintenance cost, USD	186,400	149,700	104,250
Unnecessary (premature) component replacements, per year	27	14	5





Initial investment— (sensors, twin, platform), USD		58,000	121,000
Simple payback— period, months		18.9	14.2
Net Present Value0 over 5 years, USD (r = 15%)		178,300	412,600

Table 1. Comparative technical and economic performance of the three maintenance strategies.

3. Results and Discussion

The comparative technical and economic results are summarized in Table 1.

The extension of mean prediction lead time from 4.2 days under the standalone classifier to 11.6 days under DT-ARUL follows directly from the use of the physics-based residual rather than the raw signal as the detection input: because the digital twin already accounts for the portion of signal variation attributable to normal load and speed changes, the residual isolates degradation-related deviation at a substantially lower magnitude threshold than a classifier attempting to separate the same deviation from a noisier, condition-confounded raw signal, allowing genuine degradation onset to be detected earlier without a corresponding increase in false alarms. This mechanism is corroborated by the simultaneous reduction in false-alarm rate, from 18.4% to 6.3%, which indicates that the improvement in lead time is not achieved by simply lowering a detection threshold across the board. The reduction in RUL prediction error, from a mean absolute error of 5.8 days under the classifier approach to 2.1 days under DT-ARUL, reflects the benefit of the Bayesian updating scheme: because the RUL estimate is treated as a distribution that narrows with each new observation rather than a single regression output recalculated independently at each time step, the final pre-failure





estimates benefit from the full accumulated observation history rather than only the most recent measurement window. The economic consequences of these technical improvements are concentrated in two areas. First, unnecessary premature replacements fell from 27 to 5 per year, directly reflecting the cost-minimizing maintenance threshold's sensitivity to the narrowing RUL distribution — the framework defers intervention as long as the expected cost of waiting remains below the expected cost of failure, rather than triggering on the first statistically significant anomaly as the classifier-only approach does. Second, unplanned downtime fell from 168 to 74 hours per year, reflecting the longer lead time's contribution to better-planned, lower-disruption interventions. Despite requiring roughly double the initial investment of the standalone classifier system, owing to the additional engineering effort required to construct and calibrate the physics-based twin, the DT-ARUL framework achieves a shorter payback period (14.2 versus 18.9 months) and more than double the five-year net present value, indicating that the marginal cost of the physics-based component is more than recovered through the combined reduction in premature replacement and unplanned downtime.

4. Conclusion

This study demonstrates that coupling a physics-based digital twin with data-driven prognosis and an explicit cost-minimizing maintenance-threshold rule yields substantially better predictive-maintenance performance than either fixed-interval scheduling or a standalone vibration classifier, both technically and economically. The proposed DT-ARUL framework extended prediction lead time by nearly threefold relative to the standalone classifier, reduced false alarms by two-thirds, and lowered annual maintenance cost by 44% relative to the fixed-interval baseline, while producing a five-year net present value more than double that of the classifier-only approach despite a higher initial investment. The practical significance of this work is that the marginal engineering cost of constructing a physics-based twin is not merely a modeling





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refinement but a direct driver of maintenance economics, since it is precisely the physical interpretability of the residual signal that enables both earlier detection and a materially more accurate remaining-useful-life estimate. Future extensions should evaluate the framework's transferability across equipment classes with more complex, multi-mode degradation behavior, incorporate spare-parts inventory optimization jointly with the maintenance-threshold decision, and validate the approach through longer-horizon field deployment capturing a larger number of natural failure events than the two-year record examined here.

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CURRENT ISSUES OF THE LEGAL REGULATION OF COEXISTENCE AGREEMENTS FOR THE USE OF TRADEMARKS

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Abstract

This article examines the theoretical and practical issues associated with the legal regulation of agreements on the joint use and coexistence of trademarks. The legal and doctrinal approaches developed in the legislation and judicial practice of China, Russia, and other foreign jurisdictions are analysed from a comparative legal perspective. Particular attention is paid to the legal nature of trademark coexistence agreements, their place within the system of intellectual property law, the rights and obligations of the parties, as well as contractual mechanisms aimed at protecting consumer interests and maintaining fair competition. The author provides a scholarly justification for treating a trademark coexistence agreement as an innominate contract in the field of intellectual property and for assessing it through the concept of a “limited derivative exclusive right.” In addition, the article formulates proposals for introducing special provisions governing trademark coexistence agreements into the Civil Code of the Republic of Uzbekistan in order to ensure clear and consistent legal regulation of these relations.

Keywords

trademark, intellectual property, exclusive right, limited derivative exclusive right, innominate contract, coexistence agreement, consent clause.

The effective legal protection of intellectual property rights is one of the fundamental prerequisites for fostering an innovation-driven economy, promoting fair competition, and safeguarding the legitimate interests of business entities. Among the various objects of intellectual property, trademarks occupy a distinctive position. A trademark serves not only as a means of distinguishing the goods and services of one undertaking from those of others, but also as a valuable intangible asset reflecting the





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right holder's business reputation, market standing, consumer confidence, and competitive advantage. Accordingly, improving the legal mechanisms governing the exercise and disposition of exclusive trademark rights has become one of the key priorities of contemporary intellectual property law.

Article 65 of the Constitution of the Republic of Uzbekistan guarantees the inviolability of private property and its protection by the State. This constitutional principle also provides the legal foundation for protecting proprietary rights relating to intellectual property objects. In addition, the Civil Code of the Republic of Uzbekistan recognizes exclusive rights to intellectual property objects and establishes the general legal framework for their exercise and protection.

In Chinese legal doctrine, the legal and theoretical approaches to trademark coexistence agreements are generally classified into three principal categories¹:

1. Prohibitive approach. According to this view, allowing multiple parties to use the same trademark may mislead consumers and create confusion regarding the commercial origin of goods or services. Such confusion undermines the essential function of a trademark as an indicator of origin and may distort fair competition in the marketplace. Consequently, proponents of this approach argue that trademark coexistence based on contractual arrangements should not be permitted.

2. Liberal approach. This position places primary emphasis on the principle of freedom of contract. Under this approach, where two or more persons possess rights relating to a trademark, they should be free to determine, by mutual agreement, the conditions under which the trademark may be used concurrently. State intervention in such private arrangements is considered unnecessary, provided that the agreement does not violate mandatory rules of civil law or competition law.

¹ Yu F. et al. Prevalence of 16S rRNA methylase genes in *Klebsiella pneumoniae* isolates from a Chinese teaching hospital: coexistence of *rmtB* and *armA* genes in the same isolate //Diagnostic microbiology and infectious disease. – 2009. – T. 64. – № 1. – P. 57-63.





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3. Functional compromise approach. This approach recognizes the legal validity of contractual arrangements governing relationships not expressly regulated by legislation, while emphasizing that such agreements must not prejudice the interests of consumers, the State, or society. Accordingly, although the parties may contractually allocate rights to the concurrent use of a trademark, the agreement should also establish safeguards ensuring that the exercise of those rights does not mislead third parties, impair market transparency, or adversely affect fair competition.

The functional compromise approach has also been reflected in Chinese judicial practice. In particular, in the Google v. Shimano case decided in 2016, the court upheld the legality of the parties' contractual arrangement for the coexistence and concurrent use of the trademark. In its reasoning, the court emphasized that the decisive criterion was whether the agreement adversely affected consumer interests. It concluded that the coexistence agreement primarily served to clarify the legal relationship between the respective trademark owners and that, given the clear distinction between the parties' fields of commercial activity, the agreement was unlikely to cause consumer confusion or disrupt the orderly functioning of the market².

According to the court, when assessing the validity of such agreements, priority may be given to the legitimate interests of trademark proprietors, provided that the agreement neither misleads consumers nor infringes upon the public interest.

Although trademark coexistence has not yet been comprehensively regulated under Chinese legislation, its legal nature has been shaped through judicial practice and academic doctrine. Coexistence agreements concluded on the basis of the principles of freedom of contract and protection of private property are generally recognized within the framework of general legal principles, provided that they do not prejudice consumer interests or undermine market order. Consequently, the functional compromise approach

² Ming Deng and Nicole Yu. Trademark Coexistence or Trademark Confusion? —A Comparative Study from Perspectives of Europe and China. China patents & trademarks No.4, 2017. — P. 74.
URL: <http://www.cpt.cn/uploadfiles/20180131121232759.pdf>





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has emerged in Chinese legal practice as the most balanced and pragmatic mechanism for governing trademark coexistence, striking an appropriate balance between the autonomy of trademark owners, consumer protection, and the maintenance of fair competition.

In the Russian Federation, the registration of trademark coexistence agreements is subject primarily to an assessment of whether the agreement is likely to mislead consumers³. However, the approach adopted by Russian courts in disputes arising from such agreements differs from the administrative examination carried out during registration. In judicial proceedings, courts generally do not reassess the potential for consumer confusion. Instead, they focus on whether the coexistence agreement was concluded with the consent of the trademark proprietor and whether it has been duly registered in accordance with the applicable legal requirements. Consequently, the validity and enforceability of the agreement are determined primarily by its compliance with statutory formalities rather than by an independent judicial evaluation of its possible impact on consumers⁴.

In international practice, the rights and obligations of the parties to a trademark coexistence agreement may include the following: the right to expand their commercial activities by registering the trademark for new categories of goods; the right to bring a claim in respect of conduct constituting a breach of the agreement; and the obligation to provide a letter of consent for the registration of the relevant trademark through a consent clause or a separate letter of consent.

The parties may also undertake to refrain from using or registering the trademark in a particular form, colour, size, or visual presentation, and to avoid incorporating

³ Заключение Палаты по патентным спорам от 21 июля 2020 г. (Приложение к решению Роспатента от 23 июля 2020 г. по заявке № 0001388077); Заключение Палаты по патентным спорам от 16 января 2019 г. (Приложение к решению Роспатента от 30 января 2019 г. по заявке № 0001328780); Заключение Палаты по патентным спорам от 20 марта 2018 г. (Приложение к решению Роспатента от 19 апреля 2018 г. по заявке № 2016722840)

⁴ Ходаков И.Д. Договоры о сосуществовании товарных знаков в российской и международной практике. Журнал Суда по интеллектуальным правам / Июнь 2021. – С. 168-169.





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certain distinctive elements of the earlier or senior trademark. A coexistence agreement may further contain a no-challenge clause, under which a party agrees not to contest the validity, registration, or use of the senior trademark, even where the proprietor of that trademark does not use it in relation to certain goods.

Other common contractual obligations include territorial, product-based, or field-of-use restrictions limiting the use of the trademark to a specified geographical area, category of goods, or sphere of commercial activity, as well as an undertaking not to seek the cancellation or revocation of the trademark's legal protection. The agreement may also contain a cooperation clause requiring the parties to take reasonable measures to reduce the risk of consumer confusion.

Furthermore, the parties may be required to refrain from any conduct capable of damaging the reputation or goodwill of the trademark or its proprietor. Finally, the agreement may impose restrictions on the disposition or exploitation of trademark rights, including, for example, a prohibition on licensing, assigning, or otherwise granting third parties the right to use the trademark^{5,6}

Furthermore, the subject matter of a trademark coexistence agreement may also encompass an undertaking to refrain from certain acts, thereby imposing negative obligations on the parties. Such obligations typically require a party to abstain from engaging in specified conduct, including the registration, use, licensing, assignment, or enforcement of trademark rights in circumstances that could conflict with the rights or legitimate interests of the other party. These negative covenants constitute an essential component of trademark coexistence agreements, as they are designed to preserve contractual equilibrium, minimize the likelihood of consumer confusion, and ensure the peaceful coexistence of similar or identical trademarks in the marketplace.⁷ On the basis

⁵ Carin Thomsen. Trademark Co-existence Agreements in the Perspective of EU Competition Law. P.31-33. URL https://gupea.ub.gu.se/bitstream/2077/32214/1/gupea_2077_32214_1.pdf

⁶ Standard form of Trademark Coexistence Agreement in the United States. URL: <https://uk.practicallaw.thomsonreuters.com>

⁷ Neil J. Wilkof, Daniel B., Christopher S.. Trade Mark Licensing. – P. 202.





of the foregoing considerations, it may be concluded that a trademark coexistence agreement cannot properly be characterized either as a licence agreement or as an agreement for the assignment or other disposition of trademark rights. Unlike a licence agreement, such an arrangement does not confer an independent right to use an earlier trademark upon another party. Nor does it operate as an assignment or transfer of the exclusive right to the trademark. Rather, its principal function is to regulate the coexistence of the parties' respective trademark rights and to establish the conditions under which similar or identical trademarks may coexist without giving rise to consumer confusion or legal conflict⁸. In legal practice, trademark coexistence agreements are, in most cases, concluded on a gratuitous basis.⁹

In the author's view, in order to eliminate the existing legal uncertainty and legislative gap surrounding trademark coexistence agreements, consideration should be given to incorporating this type of agreement into the system of contracts governing the disposition of exclusive intellectual property rights. Such legislative recognition would establish a clearer legal framework for regulating the rights and obligations of the parties and would strengthen the enforceability of coexistence arrangements.¹⁰

Accordingly, where two or more trademark proprietors intend to use identical or similar trademarks in relation to the same category of goods, and such concurrent use does not adversely affect the public interest, the law should permit the conclusion of a trademark coexistence agreement as an appropriate legal instrument. In light of the comparative analysis of the legislation and legal practice of several foreign jurisdictions, it is proposed that the Civil Code of the Republic of Uzbekistan be supplemented with a separate legal framework governing Trademark Coexistence Agreements.

On the basis of the foregoing analysis, the following definition may be proposed:

⁸ Parsons G., Whittingham S. Merck Global v Merck US: the intricacies of co-existence agreements //Journal of Intellectual Property Law & Practice. Journal of Intellectual Property Law & Practice, Volume 13, Issue 7, July 2018, Pages 521–523, <https://doi.org/10.1093/jiplp/jpy054>

⁹ Offner E. D. Trademark licensing in foreign countries //J. Pat. Off. Soc'y. – 1958. – Т. 40. – P. 178.

¹⁰ Елисеев В.И. Соглашения на регистрацию и соглашения о сосуществовании товарных знаков. //Патенты и лицензии. Интеллектуальные права, – № 3. Март. – 2017. – С. 66.





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A trademark coexistence agreement is a bilateral or multilateral agreement under which the proprietor of a trademark grants one or more interested parties consent to register, own, and use identical or confusingly similar trademarks. Such an agreement may be concluded either for consideration or on a gratuitous basis. However, the holder of the derivative right acquired under the agreement shall not be entitled to dispose of the trademark right or otherwise transfer the exclusive right to third parties.

The Law of the Republic of Uzbekistan “On Trademarks, Service Marks and Appellations of Origin” of 30 August 2001 does not regulate the concurrent use of trademarks by multiple persons as an independent legal institution. Consequently, trademark coexistence agreements are not expressly governed under the existing legislative framework and may only be interpreted indirectly through certain statutory provisions. In particular, the second and third paragraphs of subparagraph 13 of Article 10(1) provide that, with the consent of the proprietor of an earlier trademark, an identical or confusingly similar mark may also be registered in the name of another person. Although this provision does not expressly regulate trademark coexistence agreements, it implicitly recognizes the legal possibility of concurrent ownership and use of similar trademarks in circumstances determined by the consent of the prior right holder.

However, the current legislation contains no comprehensive legal mechanism governing the conditions for trademark coexistence, the rights and obligations of the contracting parties, the relationship between such agreements and licensing, assignment, inheritance, or pledge of trademark rights, or the allocation of liability for defective goods marketed under coexisting trademarks. Consequently, a trademark coexistence agreement cannot properly be classified as either a licence agreement, an agreement on the assignment of exclusive rights, or an agreement involving the waiver or abandonment of trademark rights.

Nor does such an agreement fall within the concept of a collective trademark as defined in Article 3(2) of the Law. A collective trademark is intended to identify the





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goods or services of members of a particular association acting in pursuit of common objectives and is based on collective ownership and use. By contrast, a trademark coexistence agreement arises from the mutual consent of two or more legally independent entities, each retaining its own separate trademark rights. Accordingly, it neither establishes collective ownership nor serves the purposes characteristic of a collective trademark.

Since a trademark coexistence agreement does not belong to any established category of intellectual property contracts—such as a licence, assignment, testamentary disposition, or other recognized form of rights transfer—the general principles of civil law should apply. In particular, Articles 103 (exercise of civil rights) and 110 (prohibition of abuse of rights) of the Civil Code of the Republic of Uzbekistan provide an appropriate normative basis for regulating such agreements. These provisions require contractual rights to be exercised in good faith, fairly, and consistently with their intended purpose, while ensuring a proper balance between the legitimate interests of the parties and preventing the abuse of subjective rights.

In light of the foregoing analysis, it is proposed that a trademark coexistence agreement should be characterized, as a matter of legal doctrine, as creating a limited derivative exclusive right. Under this concept, the primary exclusive right is the full statutory right vested in the proprietor of the earlier trademark, whereas the derivative right is a subsequently created and legally dependent right that is derived from, and exercised within the limits established by, the primary right.

A derivative exclusive right does not exist independently of the primary right. Rather, it is contingent upon the continued existence of the earlier trademark right and is contractually limited in its duration, scope, and content. Such a right is not protected as an autonomous exclusive right acquired through an independent trademark registration. Instead, it arises directly from the consent of the proprietor of the earlier trademark and exists only to the extent permitted by the coexistence agreement.





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Accordingly, this legal relationship preserves the superior legal position of the proprietor of the earlier trademark while conferring upon the other party only a limited and conditional right to register and use a similar or identical trademark. Consequently, the derivative right does not include the power to dispose of the trademark, grant licences, assign the right, or otherwise transfer it to third parties.

The legal regulation of trademark coexistence agreements in Uzbekistan remains insufficiently developed. Since the current legislation contains no specific provisions governing such contractual relationships, disputes arising from them must be resolved primarily on the basis of the general principles of civil law. From a doctrinal perspective, classifying the rights arising under a trademark coexistence agreement as a limited derivative exclusive right provides a coherent theoretical framework for explaining their legal nature. At the same time, legislative intervention is desirable in order to establish clear statutory rules governing the formation, operation, and enforcement of this contractual institution. A limited derivative right should therefore be understood not as an independent exclusive right but as a civil-law entitlement exercised solely with the consent and under the control of the proprietor of the primary trademark. By its nature, it is derivative, existing only because of, and remaining legally dependent upon, the primary exclusive right.

In the context of trademark coexistence, the derivative right holder is entitled to use the trademark only within the limits expressly provided by the agreement. In particular, the derivative right holder is not entitled to:

- grant licences to third parties in respect of the trademark;
- assign, sell, donate, exchange, pledge, or otherwise dispose of the trademark right;
- waive the right or transfer it through any other legal transaction; or
- independently renew the term of trademark protection, as any renewal must be carried out with the consent of the proprietor of the primary trademark.

Accordingly, the derivative right is strictly limited with respect to its scope, duration,





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legal powers, and capacity for disposition, and it exists exclusively within the legal sphere determined by the proprietor of the primary trademark. It does not provide comprehensive legal protection equivalent to that enjoyed by the proprietor of the trademark; rather, it confers only a limited contractual entitlement to use the trademark for agreed purposes. Its principal objective is to enable a third party to derive legitimate commercial benefits from the coexistence arrangement without prejudicing the commercial interests or exclusive legal position of the proprietor of the earlier trademark.

In order to provide legal certainty, it is proposed that the Civil Code of the Republic of Uzbekistan be supplemented with a new Article 1106¹, entitled “Trademark Coexistence Agreement.” This provision should define a trademark coexistence agreement as a conditional and limited civil-law relationship under which, with the written consent of the proprietor of an earlier trademark, one or more third parties may register and use an identical or confusingly similar trademark solely in relation to the goods or services covered by the earlier trademark.

The proposed article should further provide that such agreements are intended to permit third parties to benefit from the commercial reputation and market recognition associated with the earlier trademark by registering and using an identical or similar trademark within an agreed sphere of commercial activity, with or without territorial limitations specified by the proprietor of the earlier trademark. The parties to such agreements should be limited to commercial legal entities and business operators.

The agreement should establish a derivative exclusive right that remains legally dependent upon the earlier trademark and continues only for the duration of the registration of that trademark. Renewal of the trademark should ordinarily require the consent of the proprietor of the earlier trademark. However, where such consent is unreasonably withheld, the derivative right holder should be entitled to apply to a court, which may, where justified by the circumstances, order the renewal of the trademark. Following such judicial renewal, the exclusive right in the renewed trademark may,





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where appropriate, pass from the original proprietor to the derivative right holders acting jointly in accordance with the statutory rules governing collective ownership.

To ensure legal certainty, it is further proposed that the Civil Code be supplemented with Article 1106², entitled “Form and Registration Requirements for a Trademark Coexistence Agreement.” This article should require that the agreement be concluded in writing and registered with the competent authority. Failure to comply with these formal requirements should render the agreement invalid.

It is also proposed to introduce Article 1106³, entitled “Remuneration under a Trademark Coexistence Agreement.” Under this provision, the derivative right holder may remunerate the proprietor of the earlier trademark by means of a lump-sum payment, periodic royalty payments, a percentage of revenue, mark-ups on wholesale prices of goods supplied by the proprietor, or any other form of consideration agreed by the parties. Consistent with international practice, however, the parties should also be free to conclude a trademark coexistence agreement on a gratuitous basis.

Finally, it is proposed to introduce Article 1106⁴, entitled “Liability of the Proprietor of the Earlier Trademark for Claims against the Derivative Right Holder.” Under this provision, where claims are brought against the derivative right holder on the ground that goods marketed under the coexistence agreement fail to comply with the agreed quality standards, the proprietor of the earlier trademark should bear subsidiary liability for such claims.

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THE LEGAL NATURE AND PROTECTION OF THE AUTHOR'S MORAL RIGHTS IN NFT TECHNOLOGY

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Abstract

This article examines the legal nature of authors' moral rights and the pressing civil law issues related to their exercise and protection in the context of the rapid development of NFT technology. It provides a theoretical and legal assessment of the legal characteristics of non-fungible tokens (NFTs) and their relationship with copyright-protected works. The study analyzes legal conflicts arising from the exercise of authors' moral rights, including the right of authorship, the right to be identified by name, the right to the integrity of the work, the right of disclosure, and the right of withdrawal within the NFT ecosystem. Particular attention is paid to the immutability of blockchain technology, the cross-border nature of NFTs, issues of determining the applicable law and jurisdiction, and the legal relationship between the rights of NFT owners and the authors' moral rights. Based on the findings, the article proposes scientific conclusions and recommendations aimed at improving legal mechanisms for the effective protection of authors' moral rights in the digital environment.

Keywords

NFT, non-fungible token, blockchain, copyright, authors' moral rights, intellectual property, intellectual creations, digital asset, digital environment, integrity of the work, right of authorship, right of disclosure, right of withdrawal, legal conflicts, civil law.

The rapid development of NFT technology has necessitated a reconsideration of the traditional institutions of copyright law, particularly authors' moral rights. By introducing a new mechanism for the circulation of copyrighted works in the digital environment, NFT tokens give rise to a number of legal challenges concerning the





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exercise of the right of authorship, the right to be identified by name, the right to the integrity of the work, the right of disclosure, and the right of withdrawal. In particular, the immutability of blockchain technology and the cross-border nature of NFTs call for a reassessment of the effectiveness of traditional mechanisms for the protection of these rights. Therefore, a comprehensive scientific examination of the legal nature of authors' moral rights, as well as the mechanisms for their exercise and protection within the framework of NFT technology, is of considerable theoretical and practical significance.

The emergence and growing circulation of NFT tokens in civil commerce have, by their very existence, prompted researchers to reconsider the need for new scholarly approaches to the protection of authors' moral rights. The distinctive characteristics of NFTs such as their cross-border nature, multifunctionality, intangible form, and technological adaptability do not fully conform to traditional legal concepts. These features justify treating NFTs as a unique legal phenomenon from the perspective of copyright law and highlight the need to reassess existing legal doctrines governing authors' moral rights in the digital environment¹.

Authors' moral rights have not remained unaffected by this transformation. Although these rights appear relatively straightforward in their traditional legal understanding, within the digital environment they embody far more complex and still insufficiently explored legal constructs. As a result, they create opportunities for the realization of legal outcomes that were previously considered unattainable, thereby necessitating a reassessment of conventional approaches to the exercise and protection of authors' moral rights in the era of NFT technology².

As derivative or secondary legal constructs, NFT tokens generally serve to integrate traditional copyright-protected works into modern civil commerce. At the same time, determining the legal nature of the relationship between an NFT token and the

¹ Savelyev, A. I. Cryptocurrencies in the System of Objects of Civil Rights // *Zakon*. 2017. No. 8. Pp. 136–153.

² Novoselova, L. A., & Polezhaev, O. A. On the Legal Regime of Civil Law Objects Represented by Digital Assets // *Zakon*. 2020. No. 11. Pp. 183–192.





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author's moral rights remains a matter of considerable importance. Equally significant is the need to define the legal content and distinctive characteristics of the internal legal relationship that arises between the NFT owner and the author of the underlying work. Addressing these issues is essential for establishing a coherent legal framework governing the interaction between NFT ownership and authors' moral rights in the digital environment³.

It should be emphasized that none of the existing theoretical approaches to understanding authors' moral rights in the context of NFT technology has yet received sufficient legal substantiation or been formally incorporated into legislation. Legal systems across different jurisdictions are only beginning to take initial steps toward conceptualizing and regulating this emerging legal phenomenon. Consequently, it remains premature to endorse any particular legal construction or to formulate a universally applicable regulatory model for governing authors' moral rights within the NFT ecosystem⁴.

The introduction of NFT tokens into civil commerce has established an entirely new legal paradigm in the field of copyright, particularly with respect to authors' moral rights. Although these rights are traditionally characterized by their inalienable nature and their non-transferability to third parties, the application of NFT technology has generated novel legal challenges concerning both their exercise and protection.

The principal legal issue arises from the potential separation between the author's moral rights and the exclusive copyright in the intellectual creation embodied in an NFT token when the latter is owned by a person other than the author. Such a separation creates a range of legal conflicts, requiring comprehensive theoretical analysis as well as practical legal solutions to reconcile the interests of authors, NFT owners, and other

³ Rozhkova, M. A. Digital Assets and Virtual Property: The Relationship Between the Virtual and the Digital // [Zakon.ru](https://zakon.ru/blog/2020/06/15/cifrovye_aktivyi_virtualnoe_imuschestvo_kak_sootnositsya_virtualnoe_s_cifrovym). 2020. Available at: https://zakon.ru/blog/2020/06/15/cifrovye_aktivyi_virtualnoe_imuschestvo_kak_sootnositsya_virtualnoe_s_cifrovym

⁴ Sannikova, L. V., & Kharitonova, Yu. S. The Legal Nature of New Digital Assets // *Zakon*. 2018. No. 9. Pp. 86-95.





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participants in the digital marketplace. First and foremost, it should be emphasized that authors' moral rights including the right of authorship, the right to be identified by name, and the right to the integrity of the work remain vested in the author irrespective of who owns the NFT token. Nevertheless, the exercise and enforcement of these rights become considerably more complex within the digital environment.

For example, the author's right to the integrity of the work may be infringed by the NFT owner. From a technical perspective, the owner may have the ability to modify the token's metadata or create derivative versions of the underlying work. In such circumstances, because the author has no control over the blockchain infrastructure itself, the effective enforcement of moral rights may be significantly constrained.

The right to be identified as the author is likewise exposed to substantial risks. If the author's name is omitted from, or inaccurately recorded in, the NFT metadata, correcting such errors may prove exceptionally difficult, or in certain cases technically impossible, owing to the immutability of blockchain technology. Consequently, the permanence that enhances the reliability of blockchain records may simultaneously undermine the effective protection of the author's right of attribution.

The right of disclosure also acquires a new legal dimension in the NFT environment. A fundamental question arises as to whether the mere minting of an NFT should be regarded as constituting the disclosure of the underlying work. If this proposition is accepted, further legal issues emerge where an NFT is created by a third party without the author's consent, raising concerns as to whether such tokenization is compatible with the author's exclusive prerogative to determine the first public disclosure of the work.

One of the most complex issues concerns the exercise of the right of withdrawal. Under the traditional doctrine of copyright law, an author may, subject to certain statutory conditions, withdraw a work before or, in some jurisdictions, even after its publication. In the NFT ecosystem, however, the immutable nature of blockchain





technology makes the technical implementation of such withdrawal virtually impossible. Even where the author seeks to exercise this right, the permanent and decentralized recording of blockchain transactions substantially limits, if not eliminates, the practical possibility of removing or revoking the NFT.

The separation between the author's moral rights and the exclusive economic rights embodied in an NFT token therefore creates a distinctive legal situation. While the NFT owner may possess the authority to transfer, sell, or otherwise dispose of the token, such ownership does not confer any legal power to interfere with the author's moral rights. Conversely, although the author formally retains those inalienable rights, the technical architecture of blockchain may significantly restrict their practical exercise and enforcement. This divergence between legal entitlement and technological reality represents one of the central challenges of contemporary copyright law in the NFT era.

At present, the overwhelming majority of NFT tokens circulating in digital markets are created primarily to authenticate, record, and facilitate the transfer of certain intellectual creations. However, most of these tokens contain no legal mechanisms addressing the protection or implementation of authors' moral rights. Although NFTs specifically designed to preserve or reinforce moral rights do exist, they remain exceptional rather than representative of prevailing market practice. This imbalance further demonstrates the need for a more coherent legal framework capable of integrating the protection of authors' moral rights into the technological architecture of NFT-based transactions⁵.

As a general rule, neither the issuer of an NFT token nor its purchaser intends to become a participant in legal relationships concerning the author's moral rights. In practice, the legal purpose (*causa*) of transactions involving the acquisition of NFT tokens is ordinarily not directed toward the exercise, transfer, or regulation of the author's moral rights. Rather, such transactions are primarily aimed at acquiring or

⁵ Kharitonova, Yu. S. Art Tokenization and Intellectual Property Law // Yurist. 2021. No. 9. Pp. 65–73.





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transferring the token itself, together with any proprietary or contractual interests associated with it. Consequently, the author's moral rights typically remain outside the immediate legal scope of NFT transactions, even though the exploitation of the token may, in practice, have a direct impact on the exercise and protection of those rights⁶.

NFT tokens that are widely circulated in modern civil commerce are designed primarily to verify and publicly demonstrate ownership of a unique digital asset rather than to safeguard or implement the author's moral rights. Accordingly, issues relating to the right of authorship, the right to the integrity of the work, and the right of withdrawal are, in most instances, regarded as secondary considerations or are overlooked altogether by the parties involved in NFT transactions⁷.

In particular, a substantial proportion of the NFT tokens issued during the 2020–2021 period possessed no independent legal significance and failed to establish any juridical connection between the digital asset and the author's moral rights.

For example, judicial practice in Singapore has developed the view that the creation of an ordinary NFT merely constitutes one method of expressing a work in an objective digital form. Under this approach, ownership of an NFT does not make the token holder a participant in legal relationships concerning the author's moral rights in the underlying work. The technical characteristics of early-generation NFTs further support this position. In most cases, NFT holders were unable to influence the author's moral rights beyond the limited rights expressly contemplated by the NFT issuer or the relevant smart contract. Consequently, within the early NFT ecosystem, the legal protection and implementation of authors' moral rights were not regarded as matters of practical importance for digital asset owners or other market participants. Instead, NFTs functioned primarily as instruments for authentication, provenance, and transfer of digital assets rather than as legal mechanisms governing the personal relationship

⁶ Entin, V. L. NFTs and Copyright: How the Technology Works and What It Brings to Intellectual Property Law // *Zakon*. 2021. No. 5. Pp. 176–185.

⁷ Ruzakova, O. A., & Grin, E. S. Application of Blockchain Technology to the Systematization of Intellectual Property Results // *Vestnik Permskogo universiteta. Yuridicheskie nauki*. 2021. No. 1. Pp. 53–65.





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between the author and the work. As the functional capabilities of NFT technology continued to evolve, market participants increasingly began to use NFTs not only as instruments for recording digital assets but also as mechanisms for documenting, managing, and transferring the legal rights associated with those assets. Consequently, NFT tokens came to represent identical or substantially similar underlying works, particularly digital artworks. This development gradually diminished the perceived uniqueness and scarcity of such assets, thereby affecting one of the principal economic attributes upon which the NFT market had initially been built.

As a result, purchasers of NFTs became concerned not only with the technological security of the digital asset but also with the legal protection of their investments. The issuance of additional NFTs linked to the same or substantially similar underlying work could significantly reduce the market value, exclusivity, and commercial attractiveness of previously issued tokens. From an investment perspective, therefore, the legal certainty surrounding the relationship between the NFT and the underlying intellectual property became increasingly important. This shift transformed NFTs from mere technological certificates of authenticity into digital assets whose economic value depends not only on blockchain technology but also on the scope, exclusivity, and enforceability of the legal rights attached to the underlying work⁸.

Accordingly, NFT owners increasingly sought to establish a form of legal exclusivity not only over the digital token itself but also over the underlying asset to which it relates. This reflected a growing demand to confer genuine exclusivity upon the digital asset, extending beyond technical ownership to encompass legal interests associated with the underlying work, including issues relating to the author's moral rights. As the holder of those inalienable rights, the author retains the capacity to influence directly the commercial exploitation of both the NFT and the intellectual creation embodied therein.

⁸ Aaron, P., & Schultz, J. The End of Ownership: Personal Property in the Digital Economy. Moscow: Delo Publishing House, RANEPa, 2019. P. 112.





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As the functions and commercial uses of NFT technology evolved, the legal interests of NFT holders gradually expanded to include aspects of the author's moral rights in the underlying work. This development rendered the original NFT model under which token holders had no legal or practical ability to affect such rights increasingly inadequate for contemporary digital markets.

Nevertheless, the legal significance of transferring an NFT token from one person to another, viewed from the perspective of the author's moral rights, remains insufficiently examined. In some circumstances, such a transfer may constitute a legally neutral act with respect to the author's personal rights, whereas in others it may produce significant legal consequences affecting the exercise or protection of those rights. The absence of a coherent doctrinal framework for distinguishing between these situations continues to create legal uncertainty.

Under the traditional approach to copyright law, once the author transfers a tangible copy of a work to a purchaser, the author inevitably relinquishes a certain degree of practical control over the exercise of his or her moral rights. The digital environment, however, presents a fundamentally different legal reality. An NFT token is not merely the digital equivalent of a physical copy of a work; rather, it functions as a unique cryptographic identifier providing authenticated access to the digital repository in which the underlying intellectual creation is stored or referenced. Consequently, the legal powers exercisable by the NFT holder are closely connected to the technical capabilities embedded within the token itself. Those capabilities are neither accidental nor autonomous they are predetermined by the person who creates or issues the NFT and defines its functional architecture and legal attributes.

The legal rationale underlying this conclusion is straightforward. Where an NFT enables its holder to perform actions capable of affecting the author's moral rights, those capabilities have necessarily been incorporated into the token by its creator during the design and minting process. Conversely, if the NFT issuer intended to prevent such





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interference, the relevant technical restrictions could have been embedded into the token or the associated smart contract from the outset. Accordingly, the extent to which an NFT holder may affect the author's moral rights is determined not solely by copyright law but also by the technological architecture governing the token.

The foregoing observations demonstrate that the direct application of traditional copyright doctrines to authors' moral rights in the NFT environment is not invariably appropriate or effective. Every legal phenomenon must be interpreted in light of the technological framework through which it is expressed and exercised. Accordingly, legal analysis of moral rights in blockchain ecosystems should take account not only of classical copyright principles but also of the technological characteristics that define the operation of digital assets.

The right to the integrity of the work provides a particularly illustrative example. Within certain NFT ecosystems, this right may become virtually self-enforcing where the technological architecture prevents any modification of the underlying work after minting. In such circumstances, even the NFT owner is technically incapable of altering the work, thereby preserving the author's original creative expression without the need for additional legal intervention. Conversely, where the relevant platform or smart contract permits the NFT holder to modify, replace, or create derivative versions of the underlying work, the author may find that the practical enforcement of the right of integrity is substantially weakened despite its continued legal existence. The effectiveness of moral rights therefore depends not only upon legal rules but also upon the technical design choices embedded within blockchain-based systems.

More broadly, the process of digitalization does not merely provide a new medium through which intellectual creations are perceived by human senses. Rather, it establishes an entirely new mode of existence for classical objects of civil law. This transformation fundamentally alters both the legal nature of such objects and the mechanisms through which they are governed, requiring copyright law to evolve in





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parallel with technological innovation rather than relying exclusively on legal concepts developed for tangible works and traditional forms of exploitation⁹.

In light of the foregoing analysis, it becomes evident that the qualification and exercise of authors' moral rights in the context of NFT technology require substantially deeper doctrinal and legal examination. NFTs possess a unique capacity to alter their legal function and practical significance depending on the intentions and economic interests of their creators, holders, and other participants in civil commerce. In this respect, NFT tokens may appropriately be characterized as legal "chameleons," whose legal attributes evolve according to the technological architecture, contractual framework, and commercial objectives governing their use.

Accordingly, the regulation of authors' moral rights within NFT ecosystems cannot rely exclusively on traditional copyright doctrines developed for tangible works and conventional methods of exploitation. Instead, it requires the development of innovative legal approaches capable of reconciling the inalienable nature of authors' moral rights with the decentralized, immutable, and programmable characteristics of blockchain technology. Such approaches should seek to preserve the fundamental principles of copyright law while accommodating the technological realities of digital assets, thereby ensuring an appropriate balance between the legitimate interests of authors, NFT holders, platform operators, and other participants in the digital economy¹⁰.

Furthermore, particular attention should be paid to the legal characterization of the very act of minting an NFT from the perspective of the author's moral rights. An important doctrinal question arises as to whether the creation of an NFT may itself be regarded as constituting the disclosure of a work. If this proposition is accepted, a further issue concerns the precise moment at which disclosure occurs: whether at the time the NFT is minted, when it is first offered for sale, or only upon its initial transfer to a

⁹ Novoselova, L. A. Tokenization of Civil Law Objects // Khozyaistvo i Pravo. 2017. No. 12. Pp. 29–44.

¹⁰ Zeilinger, M. Digital art as 'monetised graphics': Enforcing intellectual property on the blockchain // Philosophy & Technology. 2018. Vol. 31(1). P. 15-41.





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purchaser. These questions remain unresolved within contemporary copyright doctrine and require comprehensive legal analysis, as well as, potentially, explicit legislative clarification.

Another significant challenge stems from the inherently global and cross-border nature of blockchain technology and NFT transactions. This characteristic substantially complicates the determination of both the applicable law and the competent jurisdiction in disputes concerning authors' moral rights. Given the decentralized structure of blockchain networks, conventional conflict-of-laws principles may prove insufficient to address such disputes effectively. Accordingly, future legal development may necessitate either the adoption of specialized international instruments governing NFT-related copyright issues or the establishment of supranational mechanisms specifically designed to resolve cross-border disputes arising within blockchain ecosystems.

The relationship between the rights of an NFT holder and the moral rights retained by the author of the underlying work likewise requires careful doctrinal reconsideration. Resolving this issue demands not only a reassessment of traditional copyright concepts but also the development of new legal constructions capable of accommodating the distinctive characteristics of digital environments. Rather than applying conventional legal principles mechanically, copyright law should evolve to reflect the technological realities of programmable digital assets while preserving the fundamental principles underlying the protection of authors' moral rights. At the same time, NFT technology also offers significant opportunities for strengthening the protection of authors' moral rights. For example, the immutability of blockchain records can provide reliable evidence of authorship, the existence of a work, and the time of its creation. Such records may therefore serve as powerful evidentiary tools in disputes concerning copyright ownership and priority. However, the practical realization of these advantages depends upon legislative recognition of blockchain records as admissible and reliable evidence in judicial proceedings, together with the establishment of procedural standards





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governing their evidentiary value. The potential impact of NFT technology on collective copyright management systems also warrants independent scholarly consideration. On the one hand, NFTs facilitate more direct legal and commercial relationships between authors and users, thereby reducing the need for traditional collective management organizations to administer licensing and royalty distribution. On the other hand, these organizations may assume new institutional functions within blockchain ecosystems, including the standardization of copyright-related NFT practices, verification of authorship and ownership, authentication of tokenized works, and certification of the legal validity of NFT transactions. Consequently, rather than rendering collective management organizations obsolete, NFT technology may fundamentally transform their institutional role within the digital copyright ecosystem.¹¹.

All of the foregoing issues warrant substantially deeper examination and broader discussion within the academic community, among legal practitioners, and by legislators. In undertaking this analysis, it is essential to recognize that NFTs should not be viewed merely as a novel technological instrument but rather as a fundamentally new form through which copyright-protected works exist, are exploited, and circulate within the digital environment. This conceptual shift has significant implications for both copyright theory and legal regulation. Accordingly, attempts to force NFTs into the framework of existing legal doctrines developed for tangible property and conventional copyright transactions are unlikely to provide satisfactory or sustainable solutions. Instead, the emergence of NFT technology calls for the development of a distinct regulatory approach that accommodates the technological characteristics of blockchain while preserving the fundamental principles of copyright law, particularly the protection of authors' moral rights. Such a framework should integrate technological innovation with established legal values, ensuring an appropriate balance between legal certainty, commercial efficiency, and the effective protection of authors in the evolving digital economy.

¹¹ De Filippi, P., & Wright, A. Blockchain and the law: The rule of code. Harvard University Press, 2018.





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TYPOLOGICAL FEATURES OF INTERNAL SYNTACTIC MODELS IN THE ENGLISH AND UZBEK LANGUAGES

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Abstract

This article examines the internal syntactic models of English and Uzbek from a typological perspective. The study focuses on word order universals, the characteristics of head-initial and head-final languages, and the comparative analysis of free and fixed word combinations. It also discusses the role of internal syntax within the hierarchy of linguistic units, its theoretical and terminological issues, and the practical significance of comparative studies for language teaching and translation studies.

Keywords

internal syntax, internal syntactic model, phrase, linguistic typology, word order universals, head-initial language, head-final language, comparative linguistics, English, Uzbek.

INGLIZ VA O‘ZBEK TILLARIDA ICHKI SINTAKTIK MODELLARNING TIPOLOGIK XUSUSIYATLARI

Karimova Nigina Sunatillo qizi (SamDCHTI)

Annotatsiya. Ushbu maqolada ingliz va o‘zbek tillaridagi ichki sintaktik modellar tipologik nuqtayi nazardan tahlil qilinadi. Tadqiqotda so‘z tartibi universalialari, markaz-boshlovchi va markaz-yakunlovchi tillarning o‘ziga xos xususiyatlari, erkin hamda turg‘un so‘z birikmalarining ichki sintaktik tuzilishi qiyosiy jihatdan yoritilgan. Shuningdek, ichki sintaksisning til birliklari tizimidagi o‘rni, uning terminologik va nazariy muammolari hamda qiyosiy tadqiqotlarning til o‘qitish va tarjimashunoslikdagi amaliy ahamiyati asoslab berilgan.

Kalit so‘zlar: ichki sintaksis, ichki sintaktik model, so‘z birikmasi, tipologiya, so‘z tartibi universalialari, markaz-boshlovchi til, markaz-yakunlovchi til, qiyosiy





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tilshunoslik, ingliz tili, o'zbek tili.

Аннотация. В статье рассматриваются внутренние синтаксические модели английского и узбекского языков с типологической точки зрения. Особое внимание уделяется универсалиям порядка слов, особенностям языков с начальнопозиционным и конечнопозиционным ядром, а также сопоставительному анализу свободных и устойчивых словосочетаний. Кроме того, освещаются место внутреннего синтаксиса в системе языковых единиц, его теоретические и терминологические проблемы, а также практическое значение результатов исследования для методики преподавания языков и переводоведения.

Ключевые слова: внутренний синтаксис, внутренняя синтаксическая модель, словосочетание, типология, универсалии порядка слов, языки с начальнопозиционным ядром, языки с конечнопозиционным ядром, сопоставительное языкознание, английский язык, узбекский язык.

Ichki sintaktik modelni tipologik jihatdan tahlil qilishda so'z tartibi universalialari muhim ahamiyat kasb etadi. J. Grinberg tomonidan aniqlangan so'z tartibi universalialari [J. Grinberg, 1963: 269] tillarni markaz va tobe komponentning o'zaro joylashuviga ko'ra ikki asosiy tipga ajratadi: markaz-boshlovchi (head-initial) va markaz-yakunlovchi (head-final). Ingliz tili, asosan, markaz-boshlovchi xususiyatga ega: markaz so'z o'zining to'ldiruvchisidan oldin keladi (*student of physics, depend on somebody*). O'zbek tili esa markaz-yakunlovchi tipga mansub: tobe komponent doimo markaz so'zdan oldin joylashadi (*fizika talabasi, kimgadir bog'liq bo'lmoq*). Bu tipologik tafovut ikki tildagi ichki sintaktik modellarning chiziqli tartibida tub farqlar mavjudligini ko'rsatadi va ularni qiyoslashning asosiy o'lchovlaridan birini tashkil etadi.

Ichki sintaksisni qiyosiy o'rganish tilshunoslik tipologiyasi bilan uzviy bog'liqdir. B. Komri til universalialari va tipologiyasiga bag'ishlangan tadqiqotida [B. Komri, 1989: 264] tillarning grammatik munosabatlarni ifodalash usullariga ko'ra





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tabaqalanishini ko'rsatib, har bir til tipida sintaktik munosabatlar o'ziga xos vositalar bilan voqelanishini asosladi. Bu yondashuv ichki sintaktik modellarni qiyoslashda muhim metodologik asos beradi: turli tipga mansub tillarda bir xil mazmuniy munosabat (masalan, egalik yoki obyektlik) turli formal vositalar bilan ifodalanadi. Shu bois ingliz va o'zbek tillaridagi ichki sintaktik modellarni qiyoslashda nafaqat shakliy, balki funksional ekvivalentlik mezoniga ham tayanish lozim, ya'ni turli vositalar bilan ifodalangan, ammo bir xil mazmuniy munosabatni anglatuvchi modellarni o'zaro qiyoslash maqsadga muvofiqdir.

Ichki sintaktik modellarning konkret ko'rinishlarini dastlabki tarzda qiyoslash ikki tildagi tafovutlarni yaqqol namoyon etadi. Sifat va ot birikuvidan iborat model (Adj + N) har ikki tilda mavjud va uning tartibi mos keladi: ingliz tilida *beautiful garden*, o'zbek tilida *chiroyli bog*, ikkala holatda ham tobe komponent markazdan oldin keladi. Ot va ot birikuv (N + N) modeli ingliz tilida keng tarqalgan (*city centre*), o'zbek tilida unga qaratqichli yoki izofali birikma mos keladi (*shahar markazi*). Fe'l va ot birikuv (V + N) modelida esa tartib farqlanadi: ingliz tilida fe'l markaz to'ldiruvchidan oldin (*read a book*), o'zbek tilida esa to'ldiruvchi fe'ldan oldin keladi (*kitob o'qimoq*). Bu dastlabki kuzatishlar ikki tildagi ichki sintaktik modellarning ham o'xshash, ham farqli jihatlarga ega ekanligini ko'rsatadi va keyingi boblarda batafsil tahlil qilinadigan muammolarni belgilaydi.

Ichki sintaksis doirasida erkin so'z birikmalari va turg'un (frazologik) birikmalarni farqlash muhim ahamiyatga ega. Erkin so'z birikmalarida komponentlar ichki sintaktik model asosida nutq jarayonida har safar yangidan birikadi va ularning ma'nosi tarkibiy qismlar ma'nosidan kelib chiqadi (*a red car, qizil mashina*). Turg'un birikmalarda esa komponentlar yaxlit, bo'linmas birlik sifatida qo'llanadi va ularning ma'nosi alohida so'zlar ma'nosidan kelib chiqmaydi (*to kick the bucket, og'ziga talqon solmoq*). Garchi ikkala turda ham tashqi tomondan bir xil ichki sintaktik model kuzatilsa-da, ularning hosil bo'lish mexanizmi tubdan farq qiladi. Mazkur





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dissertatsiyada, asosan, erkin soʻz birikmalarining ichki modellari tahlil qilinadi, zero ular tilning produktiv sintaktik imkoniyatlarini toʻliq aks ettiradi.

Ichki sintaktik modellarni qiyosiy oʻrganishning amaliy ahamiyati ham katta. Ingliz va oʻzbek tillaridagi ichki sintaktik modellarning tafovutlari til oʻrgatish jarayonida oʻziga xos qiyinchiliklarni keltirib chiqaradi: oʻzbek oʻquvchilari ingliz tilidagi markaz-boshlovchi tartibni (*read a book*), ingliz oʻquvchilari esa oʻzbek tilidagi markaz-yakunlovchi tartibni (*kitob oʻqimoq*) oʻzlashtirishda interferensiya hodisasiga duch keladi. Tarjima jarayonida ham ichki sintaktik modellarning farqi muhim rol oʻynaydi: bir tildagi modelni ikkinchi tilga oʻgʻirishda komponentlar tartibi va bogʻlanish vositalari oʻzgarishi zarur boʻladi. Shu bois ichki sintaktik modellarni tizimli qiyoslash til oʻqitish metodikasini takomillashtirish va tarjima sifatini oshirishga xizmat qiladi, bu esa tadqiqotning amaliy qiymatini belgilaydi.

Ichki sintaksisning sintaktik birliklar tizimidagi oʻrnini aniqlash uchun til birliklari ierarxiyasiga murojaat qilish lozim. Til birliklari murakkablik darajasiga koʻra quyidagi pogʻonali tizimni hosil qiladi: morfema $\rightarrow$ soʻz $\rightarrow$ soʻz birikmasi $\rightarrow$ gap $\rightarrow$ matn. Ushbu ierarxiyada soʻz birikmasi soʻzdan yuqori, gapdan quyi sathda joylashadi va shu bois u oʻziga xos ikki yoqlama tabiatga ega boʻladi. Bir tomondan, soʻz birikmasi oʻz komponentlarining ichki sintaktik bogʻlanishi natijasida hosil boʻladigan mahsul (ichki sintaksisning obyekti)dir. Ikkinchi tomondan, u oʻzi gap tarkibiga kirib, undagi sintaktik vazifani bajaruvchi tarkibiy qism (tashqi sintaksisning birligi)dir. Demak, ichki sintaksis soʻz birikmasini “ichkaridan”, uning hosil boʻlish mexanizmi nuqtayi nazaridan, tashqi sintaksis esa “tashqaridan”, uning gapdagi funksiyasi nuqtayi nazaridan oʻrganadi. Aynan shu ikki yoqlama tabiat soʻz birikmasini butun sintaktik tizimning markaziy boʻgʻiniga aylantiradi.

Taʼkidlash joizki, ichki sintaksis konsepti yetarlicha ishlab chiqilganiga qaramay, bir qator masalalar hanuzgacha munozarali boʻlib qolmoqda. Birinchidan, ichki sintaksisning maqomi borasida yagona qarash yoʻq: ayrim tadqiqotchilar uni mustaqil





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nazariy sath sifatida ajratsa, boshqalari soʻz birikmasi sintaksisining bir qismi sifatida qaraydi. Ikkinchidan, terminologik nomuvofiqlik kuzatiladi: ichki sintaksis, kichik sintaksis, mikrosintaksis va soʻz birikmasi sintaksisi atamaları koʻpincha bir-birini qoplab, ammo toʻliq mos kelmaydi. Uchinchidan, ayniqsa agglutinatív tillar uchun dolzarb boʻlgan masala, ichki sintaksis bilan morfologiya oʻrtasidagi chegara muammosidir. Bu masala oʻzbek tilida soʻz birikmasi ichidagi bogʻlanishning koʻp hollarda affiksál vosítalar orqali ifodalanishi bilan murakkablashadi.

Soʻz birikmasi tushunchasini ifodalovchi atamalarning oʻzi ham tarixiy va tarjimaviy jihatdan diqqatga sazovor. Rus tilshunosligidagi словосочетание atamasi “soʻzlarning birikuvi” maʼnosini anglatib, V.V. Vinogradov davridan boshlab terminologik aniqlik kasb etgan. Gʻarb anʼanasidagi phrase atamasi esa kengroq maʼnoga ega boʻlib, u nafaqat tobe birikmani, balki har qanday frazaviy birlikni (NP, VP, PP) qamrab oladi. Oʻzbek tilshunosligida qoʻllanadigan soʻz birikmasi atamasi словосочетание atamasining izchil tarjimasi sifatida shakllangan va oʻzbek grammatik anʼanasida mustahkam oʻrin egallagan. I.P. Susov tilshunoslik tarixiga bagʻishlangan tadqiqotida [I.P. Susov, 2006: 295] sintaktik atamalarning shakllanish jarayonini yoritib, ularning turli maktablarda turlicha hajmga ega ekanligini taʼkidlaydi. Bu terminologik tafovutlar ichki sintaksisni qiyosiy oʻrganishda atamalarni aniq belgilab olish zaruratini keltirib chiqaradi.

Ichki sintaksis doirasiga qaysi munosabatlar kirishi masalasi alohida muhokamaga sazovor. Anʼanaviy qarashga koʻra (Vinogradov), ichki sintaksis faqat tobe (subordinativ) bogʻlanishni qamrab oladi, predikativ va teng bogʻlanish esa undan tashqarida qoladi. Biroq ayrim tadqiqotchilar predikativ birikmalarni ham (masalan, ingliz tilidagi nexus konstruksiyalari yoki oʻzbek tilidagi ega-kesim munosabati) ichki sintaktik tahlil doirasiga kiritishni taklif etadilar. Fikrimizcha, predikativ munosabat oʻz tabiatiga koʻra gap sathiga taalluqli boʻlib, ichki sintaksis, asosan, tobelik munosabatini oʻrganadi. Teng bogʻlanishli birikmalar (*bread and butter, ota va ona*) esa oʻziga xos





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oraliq holatni egallaydi: ularda markaz–tobe ierarxiyasi bo‘lmaydi, shu bois ularni ichki sintaksisning alohida turi sifatida ko‘rib chiqish maqsadga muvofiqdir.

Maqolada ingliz va o‘zbek tillaridagi ichki sintaktik modellar tipologik va qiyosiy nuqtayi nazardan tahlil qilinib, mazkur tillarning sintaktik qurilishida mavjud umumiylik hamda o‘ziga xos xususiyatlar yoritildi. Tadqiqot natijalari so‘z tartibi universalialari, markaz-boshlovchi va markaz-yakunlovchi tillar o‘rtasidagi farqlar ichki sintaktik modellar shakllanishiga bevosita ta’sir ko‘rsatishini tasdiqlaydi. Shu bilan birga, erkin so‘z birikmalarining ichki tuzilishi va ularning funksional ekvivalentligi qiyosiy tahlil uchun muhim metodologik asos bo‘lib xizmat qilishi asoslandi.

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