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Tashkent International University of Education
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PROCEEDINGS

of the MMIT'25 International Conference

TA'LIMNING ZAMONAVIY USULLARI VA
INNOVATSION TEXNOLOGIYALAR

MODERN METHODS AND INNOVATION
TECHNOLOGIES IN EDUCATION

СОВРЕМЕННЫЕ МЕТОДЫ И
ИННОВАЦИОННЫЕ ТЕХНОЛОГИИ
В ОБРАЗОВАНИИ

29 May 2025, Tashkent, Uzbekistan

MAQOLALAR TO'PLAMI
СБОРНИК СТАТЕЙ



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**Современные методы и инновационные технологии в
образовании**

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MUSTAQIL TRAYEKTORIYALI OBYEKTЛАRNI QAYTA IDENTIFIKATSIYALASH MASALASI

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Annotatsiya. Ko'p obyektli kuzatuv (Multi-Object Tracking, MOT) tizimlari zamonaviy kompyuter ko'rish va sun'iy intellekt sohalarining muhim yo'nalishlaridan biri bo'lib, ular real vaqtda harakatlanayotgan bir nechta obyektlarni aniqlash va ularni kuzatib borishga mo'ljallangan. Ko'p obyektli kuzatuv tizimlari nafaqat obyektни aniqlash, balki uni vaqt bo'yicha ketma-ket kadrlar orqali identifikatsiyalash imkonini beradi. Shunga qaramay, ko'p obyektli kuzatuv tizimlarining aniqligi va ishonchliligi bir qator texnik muammolar bilan cheklanadi. Xususan, obyektlarning bir-birini to'sib qo'yishi (occlusion), ya'ni bitta obyekt vaqtincha boshqa obyekt yoki fon tomonidan yashirilishi, kuzatuv aniqligini pasaytiradi. Bunday holatlarda, kuzatuv tizimi obyektни yo'qotib qo'yishi yoki boshqa obyekt bilan chalkashtirib yuborishi mumkin. Bundan tashqari, obyektlar vaqtincha kameraning ko'rish doirasidan chiqib ketishi yoki yorug'lik, harakat tezligi, fonning murakkabligi kabi omillar ham kuzatuvning aniqligiga salbiy ta'sir ko'rsatadi. Ushbu muammolarni bartaraf etish maqsadida zamonaviy ko'p obyektli kuzatuv tizimlarida chuqur o'rganish (deep learning), konvolyutsion neyron tarmoqlar (CNN), rekurrent neyron tarmoqlar (RNN), transformer arxitekturası, obyektни re-identifikatsiyalash (Re-ID) texnologiyalari kabi ilg'or algoritmlardan foydalaniladi. Ayniqsa, obyektlarning harakat trayektoriyalarini bashorat qilish, shuningdek, vaqtincha yo'qolgan obyektlarni aniqlash va qayta tiklash uchun modellar keng qo'llanmoqda.

Kalit so'zlar: ko'p obyektli kuzatuv, qayta identifikatsiya, nazorat qilinmagan o'rganish, to'silishni baholash, cosine similarity, occlusion xaritasi, Gauss yadrosi, real vaqtli kuzatuv tizimlari.

RE-IDENTIFICATION PROBLEM FOR OBJECTS WITH INDEPENDENT TRAJECTORIES

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Abstract. Multi-Object Tracking (MOT) systems are one of the important areas of modern computer vision and artificial intelligence, designed to detect and track multiple objects moving in real time. Multi-object tracking systems allow not only to identify the object, but also to identify it through sequential frames over time. Nevertheless, the accuracy and reliability of multi-object surveillance systems are limited by a number of technical problems. In particular, the occlusion of objects, that is, the temporary concealment of one object by another object or background, reduces the accuracy of observation. In such cases, the tracking system may lose the object or confuse it with another object. Additionally, factors such as objects temporarily leaving the camera's field of view or light, speed of movement, and background complexity also negatively affect observation accuracy. To eliminate these problems, advanced algorithms such as deep learning, convolutional neural networks (CNN), recurrent neural networks (RNN), transformer architecture, and object re-identification (Re-ID) technologies are used in modern multi-object tracking systems. In particular, models are widely used for predicting the trajectories of objects, as well as for identifying and restoring temporarily lost objects.

Keywords: multi-object tracking, re-identification, uncontrolled learning, barrier estimation, cosine similarity, occlusion map, Gaussian kernel, real-time tracking systems.

Kirish

Hozirgi kunda ko'p obyektli kuzatuv texnologiyalari (computer vision) kompyuter ko'rish tizimi sohasining eng dolzarb yo'nalishlaridan biri hisoblanadi. Ushbu tizimlar video tahlili, ommaviy xavfsizlik nazorati, avtonom transport vositalari, aqlli shahar infratuzilmalari, robototexnika, sport tahlili, qishloq xo'jaliklari va sog'liqni saqlash kabi sohalarda keng qo'llaniladi. Ushbu tizimlarda asosiy vazifa — har bir kadrda obyektlarni aniqlab, ularni vaqt bo'yicha uzluksiz ravishda kuzatib borishdan iborat.

So'nggi yillarda obyekt aniqlash algoritmlarining rivojlanishi ko'p obyektli kuzatuv tizimlarining aniqligini sezilarli darajada oshirdi. Biroq, obyektlar orasida yuz beradigan to'silishlar (occlusion) va aniqlovchi (detector) tomonidan obyektning vaqtincha yo'qolishi kabi holatlar hali ham katta muammo bo'lib qolmoqda. Bu esa obyektning identifikatsiya raqamini yo'qotish yoki obyekt identifikatsiyasida chalkashlik (noto'g'ri moslashtirish) yuzaga kelishiga olib keladi.

An'anaviy yechimlarda bu muammo obyektlar qayta ko'rinishda ularni Re-ID (re-identification) moduli yordamida aniqlash orqali bartaraf etiladi. Ammo mavjud Re-ID modullar ko'pincha identifikatsiya etiketkalariga (ID) asoslangan bo'lib, ularni tayyorlash katta mehnat va resurs talab etadi. Shu sababli, maqolada nazorat qilinmagan (unsupervised) Re-ID yondashuvi taklif etiladi. Bunda obyektlar orasidagi ko'rinish o'xshashligi asosida Re-ID o'rgatiladi va identifikatsiya ma'lumotlariga ehtiyoj qolmaydi.

Bundan tashqari, maqolada to'silgan obyektlarni aniqlash uchun maxsus **to'silishni baholovchi modul** (occlusion estimation) ham qarab chiqilgan. Bu modul kadr ichida qaysi joylarda obyektlar to'silib qolganini bashorat qiladi va yo'qolgan obyektlarning taxminiy joylashuvini aniqlash orqali kuzatuv aniqligini tiklaydi.

Natijalar va muhokama

Ko'p obyektli kuzatuv kompyuter ko'rish tizimlarining asosiy komponentlaridan biri bo'lib, video oqimlarida bir nechta obyektlarni aniqlash va ularni vaqt bo'yicha kuzatib borishni ta'minlaydi. Ushbu texnologiya nafaqat avtonom transport vositalari va xavfsizlik kameralarida, balki ommaviy yig'inlar, sport tahlillari, qishloq xo'jaliklarida va tibbiyotda ham keng qo'llaniladi. Kompyuter ko'rish tizimlarining tizimlari asosan "aniqlash orqali kuzatuv" (tracking-by-detection) tamoyiliga asoslanadi, ya'ni har bir kadrda obyektlar aniqlanadi va keyingi kadrlar bilan bog'lanadi.

Ammo ushbu yondashuvning asosiy muammolaridan biri shundaki, ba'zi obyektlar vaqtincha ko'rinmas holga keladi (masalan, boshqa obyekt tomonidan to'silishi yoki kameradan chiqib ketishi sababli) va bu holatda ularni qayta aniqlash qiyinlashadi. Aynan shu muammoni hal qilish uchun qayta identifikatsiya (Re-ID) tizimlari qo'llaniladi [1].

Mazkur maqolada ko'p obyektli kuzatuv tizimlarining ikkita innovatsion moduli taklif etiladi: **nazorat qilinmagan qayta identifikatsiya (Re-ID) moduli** va **to'silishni baholash moduli**.

Re-ID moduli obyektlarning ketma-ket kadrlar orasidagi ko'rinish o'xshashligiga asoslanib, ularni identifikatsiya etiketkalari (ID) talab qilmasdan aniqlaydi. Bu modul video yoki tasvirli ma'lumotlar asosida o'qitilishi mumkin va katta hajmdagi ma'lumotlar bilan samarali ishlaydi. Shu bilan birga, to'silishni baholash moduli kadr ichida obyektlar o'zaro ustma-ust joylashgan joylarni aniqlaydi va yo'qolgan obyektlarning taxminiy holatini bashorat qilish orqali ularni kuzatuvga qaytaradi.

Re-ID tizimlari va ularning cheklovlari. Re-ID modullari har bir obyektning vizual xususiyatlariga asoslanib qayta tanib olishni maqsad qiladi. Ko'pgina ko'p obyektli kuzatuv tizimlari Re-ID ni amalga oshirishda oldindan tayyor va qo'lda belgilanuvchi identifikatsiya qilingan ma'lumotlar to'plamidan foydalanadi. Biroq bu usul quyidagi cheklovlarga ega:

Ko'p miqdordagi ID annotatsiyalar kerak bo'ladi – bu esa vaqt va resurs jihatidan juda qimmat.

O'lchamlilik muammosi (scalability) – Re-ID klassifikatori har bir shaxs uchun alohida sinf yaratadi, bu esa katta ma'lumotlar bazalarida samaradorlikni pasaytiradi.

Moslashuvchanlik past – turli sahnalar va turli sharoitlarda bir xil obyektning aniqlash qiyinlashadi.

Shu sababli, nazorat qilinmagan Re-ID moduli taklif qilinib, bu modul ketma-ket kadrlar orasidagi obyektlarning ko'rinish o'xshashligiga asoslanib, identifikatsiya ma'lumotlarisiz o'qitiladi [2].

Nazorat qilinmagan Re-ID moduli asosida obyektlar orasidagi cosine similarity (kosinus o'xshashlik) hisoblanadi. Bu usulda har bir obyekt vektor sifatida ifodalanadi va ular orasidagi o'xshashlik quyidagicha aniqlanadi:

$$S_{i,j} = \frac{f_i f_j}{\|f_i\| \|f_j\|},$$

bu yerda f_i va f_j obyektlarning belgi (feature) vektorlari. Bu o'xshashlik matritsasi asosida assignment matrix (o'zlashtirish matritsasi) yaratiladi va obyektlar orasidagi bog'liqlik aniqlanadi.

Re-ID yo'qotish funksiyasi quyidagi tarkibiy qismlardan iborat:

Intra-frame loss (L_{intra}): bir kadr ichidagi obyektlar bir-biriga moslanmasligi kerak.

Inter-frame loss (L_{inter}): obyektlar ketma-ket kadrlar orasida bir xil bo'lishi ehtimoli yuqori.

Cycle consistency loss (L_{cycle}): bog'lanish ikki yo'nalishda mos bo'lishi kerak ($i \rightarrow j \rightarrow i$).

Yuqoridagi yo'qotish funksiyalari yordamida model obyektlar orasidagi o'xshashlikni o'rganadi va ularni identifikatsiya etiketkasisiz bog'lash mumkin bo'ladi [3].

To'silish baholash moduli. Ko'p obyektli kuzatuv tizimlarida obyektlarning bir-birini to'sib qo'yishi yoki fon bilan birlashib ketishi holatlari kuzatuv aniqligini keskin pasaytiradi. Shu sababli, ushbu muammoni bartaraf etish uchun maqolada to'silishni baholovchi maxsus modul ishlab chiqilgan. Ushbu modulning asosiy vazifasi – obyektlar to'silgan holatlarda ularning mavjudligini aniqlash va taxminiy joylashuvini aniqlash orqali kuzatuvni davom ettirishdir.

To'silishni baholovchi modul vizual ma'lumotlar asosida occlusion xaritasini hosil qiladi. Bu xarita obyektlar orasidagi ustma-ust joylashuvni, ya'ni to'silgan holatlarni aniqlaydi [1]. Xarita Gauss yadrosi asosida yaratiladi va unda har bir to'silgan obyektning markaziy koordinatalari aniqlanadi. Bu markazlar keyinchalik kuzatuv algoritmlari, xususan Kalman filter va Re-ID belgilar bilan birgalikda ishlatiladi.

Modulning ishlashi ikki asosiy matematik elementga tayanadi:

1. To'silish indikator funksiyasi – funksiya qaysi obyektlar bir-birini to'sib turganini aniqlaydi. Agar ikki obyekt orasidagi ustma-ust maydon ma'lum chegaradan katta bo'lsa, ular to'silgan deb belgilanadi.

2. Gauss yadrosi yordamida to'silgan markazlarni aniqlash – markazlar asosida xarita hosil qilinadi va kuzatuv algoritmgacha qo'shiladi.

Eksperimentlar shuni ko'rsatdiki, bu modul qo'llanilganida ayniqsa obyektlar zich joylashgan yoki murakkab sahnalarda kuzatuv aniqligi, identifikatsiya ishonchliligi sezilarli darajada oshadi [1].

To'silishni baholovchi modul yordamida kuzatuv uzluksizligi ta'minlanadi va yo'qolgan obyektlarni yangilash imkoniyati yaratiladi. Bu esa ko'p obyektli kuzatuv tizimlarining real sharoitlarda, ayniqsa xavfsizlik va avtonom transport tizimlarida yanada ishonchli ishlaydi.

Xulosa

Ko'p obyektli kuzatuv tizimlarida kuzatilayotgan asosiy muammolar – obyektlarning vaqtincha yo'qolishi va to'silishi – uchun samarali yechim sifatida nazorat qilinmagan qayta

identifikatsiya moduli va to'silishni baholash modulini taklif qiladi. Re-ID moduli obyektlarni identifikatsiya ma'lumotlarisiz, ya'ni qo'lda belgilangan ID'larsiz o'qitish imkonini berib, tizimning o'lchamlilik va moslashuvchanlik darajasini sezilarli oshiradi. Shu bilan birga, to'silishni baholash moduli yordamida kadrda boshqa obyektlar tomonidan yopilgan, ammo harakatlanayotgan obyektlarning joylashuvi aniqlanib, kuzatuv davom ettiriladi. Bu yondashuv mavjud kuzatuv tizimlariga oson integratsiya qilinadi va kuzatuv aniqligi, barqarorligi va samaradorligini oshiradi. Ushbu metodologiya real vaqtli video kuzatuv tizimlari uchun yuqori amaliy ahamiyatga ega bo'lib, kelgusida yanada murakkab muhitlarda qo'llanish imkoniyatiga ega.

Adabiyotlar ro'yxati

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An abstract graphic featuring a complex network of interconnected nodes and lines, resembling a molecular structure or a digital network, set against a dark blue background. The nodes are represented by circles of varying sizes, and the lines are thin, light blue, creating a web-like pattern that fills the upper two-thirds of the page.

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