

VIDEO-TASVIRLARDA HARAKATDAGI OBYEKTLARNI ANIQLASHNING INTELLEKTUAL TIZIMINI ISHLAB CHIQISH

Obilov Bahodir Voxobjon o'g'li

Toshkent Kimyo xalqaro universiteti Namangan filiali, magistranti.

Annotatsiya. Ushbu maqolada video oqimlarda harakatdagi obyektlarni aniqlash va kuzatish uchun zamonaviy intellektual tizim arxitekturasi taklif etiladi. Maqola YOLO, Faster/Mask R-CNN, SSD, DETR kabi detektorlar hamda SORT/DeepSORT, FairMOT, ByteTrack singari ko'p obyektli kuzatuv (MOT) usullari tahliliga tayangan holda, real vaqt talablari (FPS), aniqlik ko'rsatkichlari (mAP, IDF1) va resurs cheklovlari o'rtasidagi muvozanatni yoritadi. Shuningdek, O'zbekistonda yo'l harakatini monitoring qilish bo'yicha nashrlardan amaliy misollar keltiriladi.

Kalit so'zlar: Kompyuter ko'rish, obyekt aniqlash, ko'p obyektli kuzatuv, YOLO, DETR, SORT, ByteTrack, FairMOT, MOTChallenge, real vaqt.

1. Kirish. Raqamli videokuzatuv va IoT qurilmalari sonining keskin ortishi natijasida yo'l harakati, xavfsizlik, sanoat va sport analitikasi kabi sohalarda harakatdagi obyektlarni aniqlash va kuzatish muammosi dolzarb tus olgan. Maqsad — past kechikish bilan yuqori aniqlikni ta'minlaydigan, modullashtirilgan va kengaytiriladigan tizim yaratish.

2. Bog'liq ishlar: adabiyotlar tahlili.

2.1. Detektorlar evolyutsiyasi

YOLO birinchi avlod usuli obyekt aniqlashni yakka tarmoq regressiya vazifasi sifatida qo'yib, real vaqtda 45+ FPS ko'rsatkichiga erishgan, ammo lokalizatsiya xatolari nisbatan ko'p bo'lgan [1]. Faster R-CNN mintaqa taklif qilish tarmog'i (RPN) orqali aniqlikni oshirgan, biroq hisoblash murakkabligi tufayli FPS past bo'lib qolgan [2, 9]. SSD ko'p o'lchamli xususiyat xaritalari va 'default box'lar orqali bir bosqichli aniqlashni tez va raqobatbardosh aniqlik bilan ta'minlagan [3, 6, 14]. Mask R-CNN esa deteksiyaga instansiya segmentatsiya tarmog'ini qo'shib, COCO yo'nalishlarida yetakchi natijalarni ko'rsatgan [4, 7]. Transformeriga asoslangan DETR qoida asosidagi NMS va ankorga bog'liqlikni olib tashlab, to'plam-prognozlash (set prediction) va bipartit moslashtirish orqali soddalashtirilgan pipeline taklif qiladi [16, 20]. So'nggi yillarda YOLOv7 [17, 21] va YOLOv8 [18, 22, 24] real vaqt rejimida aniqlik-tezlik muvozanatini yanada yaxshiladi.

2.2. Ko'p obyektli kuzatuv (MOT).

SORT Kalman filtri va Vengercha (Hungarian) moslashtirish asosida juda tez ishlaydigan onlayn kuzatuvni ta'minlaydi [10, 13]. Deep SORT ko'rinish (appearance) embeddinglari bilan ID almashinishlarni keskin kamaytiradi [5, 19]. FairMOT deteksiya va re-ID ni yagona, adolatli ko'p-vazifali tarmoqda birlashtiradi [7]. ByteTrack past baholangan deteksiya qutillarini ham assotsiatsiyaga jalb qilib, MOT17 va MOT20 setlarida MOTA/IDF1 bo'yicha SOTA natijalarni qayd etadi [6, 8, 11, 12]. Yaqinda sport sahnalariga moslashtirilgan HM-SORT kabi variantlar ham taklif qilinmoqda [15].

2.3. Benchmarklar va metrikalar

MOTChallenge (MOT15/16/17/20) kuzatuv usullarini standart baholash uchun keng qo'llanadi; ayniqsa MOT20 juda gavjum sahnalarni o'z ichiga oladi [23, 25, 26]. Detektorlar uchun COCO va VOC mAP; kuzatuv uchun MOTA, IDF1, HOTA va ID-switch ko'rsatkichlari ishlatiladi.

2.4. O'zbekistonda amaliy tadqiqotlar

Toshkent sharoitida real vaqt transport oqimini hisoblash va monitoring qilishga bag'ishlangan tadqiqotlar, masalan, Sensors jurnalida chop etilgan ishda, deteksiya va kuzatuv integratsiyasi orqali tirbandlikni kamaytirish maqsad qilingan [27, 29]. Shuningdek, mahalliy mualliflar tomonidan yo'l harakati va video-kuzatuvga doir ishlanmalar ham uchraydi [30–32].

3. Taklif etilayotgan tizim arxitekturasi

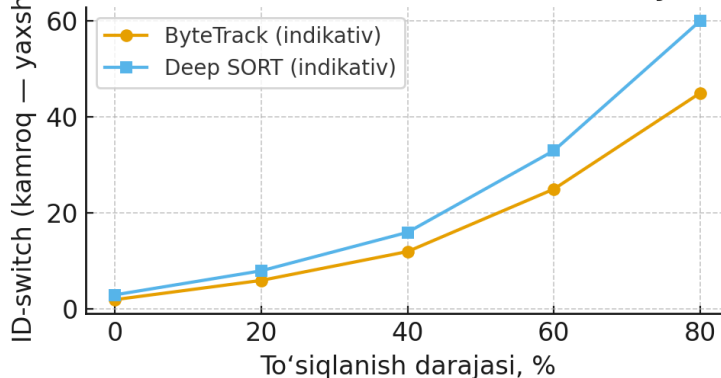
Tizim pipeline'i: (i) Kadrlarni olish va oldindan ishlov; (ii) Detektor (YOLOv8 yoki YOLOv7/SSD) orqali obyektlarni aniqlash; (iii) MOT moduli (ByteTrack yoki Deep SORT) orqali identifikatsiya va trayektoriya yangilash; (iv) Analitika (hisoblash, zonalar bo'yicha oqim, qoidabuzarliklar). Edge qurilmalar uchun yengil modellar (YOLO-Nano/YOLOv8n) qo'llanadi, markaziy serverda esa ko'proq aniqlik talab qiluvchi modellar ishga tushiriladi.

Video kadrlar → Oldindan ishlov → Detektor (YOLOv8/SSD) → Kuzatuv (ByteTrack/DeepSORT)

4. Eksperimental dizayn va muhokama (konseptual)

Maqsad — real vaqt (≥ 25 FPS) va barqaror IDF1 ni ta'minlash. Detektor tanlovi sahna murakkabligiga bog'liq: oddiy sahnalar uchun YOLOv8n/s, murakkab sahnalar uchun YOLOv8m/l yoki YOLOv7. Kuzatuvda ByteTrack occlusion holatlarida ham deteksiya qutillarini to'liqroq hisobga olib, ID-switch'larni kamaytirishga yordam beradi [11, 12].

Occlusion oshishi bilan ID-switch tendensiyasi (shema)



Eslatma: grafik indikativ bo'lib, umumiy tendensiyani ko'rsatadi. Aniq raqamlar ma'lum bir model, dataset va apparatga bog'liq ravishda o'zgaradi.

5. Amaliy qo'llanma

- Chegaraviy qurilmalar (edge) uchun: YOLOv8n/s + ByteTrack; 720p@25–30 FPS.
- GPU serverlarida: YOLOv8m/l yoki YOLOv7 + ByteTrack/DeepSORT; 1080p@30 FPS.
- Monitoring: zonalar, hisoblagichlar, qoidabuzarliklar (masalan, taqiqlangan zona), issiqlik xaritalari.
- Modelni moslashtirish: sinflar soni, aniq sahna sharoitlari (tun/ob-havo) uchun finetune.

6. Xulosa

Deteksiya va kuzatuv modullarini to'g'ri juftlash real vaqt tizimlarida barqaror ishlashni ta'minlaydi. YOLOv7/YOLOv8 kabi zamonaviy detektorlar ByteTrack/FairMOT bilan birga gavjum sahnalarda yuqori IDF1 ko'rsatish imkonini beradi. Kelgusida transformer-asosli detektorlar (DETR va uning variantlari) va self-supervised pre-treninglar balansini o'rganish maqsadga muvofiq.

7. Foydalanilgan adabiyotlar

- [1] Redmon J., et al. "You Only Look Once: Unified, Real-Time Object Detection." arXiv:1506.02640, 2015. <https://arxiv.org/abs/1506.02640>
- [2] Ren S., et al. "Faster R-CNN: Towards Real-Time Object Detection with Region Proposal Networks." arXiv:1506.01497, 2015. <https://arxiv.org/abs/1506.01497>
- [3] Liu W., et al. "SSD: Single Shot MultiBox Detector." arXiv:1512.02325, 2015 / ECCV 2016. <https://arxiv.org/abs/1512.02325>
- [4] He K., et al. "Mask R-CNN." arXiv:1703.06870, 2017. <https://arxiv.org/abs/1703.06870>
- [5] Wojke N., et al. "Simple Online and Realtime Tracking with a Deep Association Metric." arXiv:1703.07402, 2017. <https://arxiv.org/abs/1703.07402>

- [6] Zhang Y., et al. “ByteTrack: Multi-Object Tracking by Associating Every Detection Box.” ECCV 2022. https://www.ecva.net/papers/eccv_2022/papers/136820001.pdf
- [7] Zhang Y., et al. “FairMOT: On the Fairness of Detection and Re-Identification in MOT.” arXiv:2004.01888, 2020. <https://arxiv.org/abs/2004.01888>
- [8] Zhang Y., et al. “ByteTrack...” arXiv:2110.06864, 2021. <https://arxiv.org/abs/2110.06864>
- [9] Ren S., et al. NIPS 2015 version. <https://proceedings.neurips.cc/paper/5638-faster-r-cnn-towards-real-time-object-detection-with-region-proposal-networks.pdf>
- [10] Bewley A., et al. “Simple Online and Realtime Tracking.” arXiv:1602.00763, 2016. <https://arxiv.org/abs/1602.00763>
- [11] ar5iv HTML of ByteTrack. <https://ar5iv.labs.arxiv.org/html/2110.06864>
- [12] ByteTrack blog explainer. <https://www.luffca.com/2023/06/multiple-object-tracking-bytetrack/>
- [13] SORT GitHub. <https://github.com/abewley/sort>
- [14] Google Research copy of SSD paper. <https://research.google.com/pubs/archive/44872.pdf>
- [15] Gran-Henriksen M., et al. “Deep HM-SORT.” arXiv:2406.12081, 2024. <https://arxiv.org/pdf/2406.12081>
- [16] Carion N., et al. “DETR: End-to-End Object Detection with Transformers.” arXiv:2005.12872, 2020. <https://arxiv.org/abs/2005.12872>
- [17] Wang C.-Y., Bochkovskiy A., Liao H.-Y.M. “YOLOv7...” arXiv:2207.02696, 2022. <https://arxiv.org/abs/2207.02696>
- [18] Ultralytics YOLO Docs (YOLOv8). <https://docs.ultralytics.com/models/yolov8/>
- [19] ResearchGate copy: Deep SORT. <https://www.researchgate.net/publication/315491564>
- [20] Springer chapter: DETR. https://link.springer.com/chapter/10.1007/978-3-030-58452-8_13
- [21] CVPR 2023 version of YOLOv7. https://openaccess.thecvf.com/content/CVPR2023/papers/Wang_YOLOv7_Trainable_Bag-of-Freebies_Sets_New_State-of-the-Art_for_Real-Time_Object_Detectors_CVPR_2023_paper.pdf
- [22] Ultralytics Docs (home). <https://docs.ultralytics.com/>
- [23] MOT20 benchmark. <https://arxiv.org/abs/2003.09003>
- [24] Ultralytics: YOLOv8 vs YOLOv5. <https://docs.ultralytics.com/compare/yolov8-vs-yolov5/>

- [25] MOT17 dataset page. <https://motchallenge.net/data/MOT17/>
- [26] MOTChallenge FAQ. <https://motchallenge.net/faq/>
- [27] Kutlimuratov A., et al. “Applying Enhanced Real-Time Monitoring and Counting Method for Effective Traffic Management in Tashkent.” *Sensors* 23(11):5007, 2023. <https://www.mdpi.com/1424-8220/23/11/5007>
- [28] ResearchGate copy (Tashkent traffic counting). <https://www.researchgate.net/publication/370997537>
- [29] Humayun M., et al. “Multi-Scale Vehicle Detection in Adverse Conditions.” *Electronics* 2022. <https://www.mdpi.com/2079-9292/11/17/2748>
- [30] Mamaraufov O. “Detection of Moving Vehicles in Road Traffic Surveillance.” *IJCSEIT*, 2015. <https://airconline.com/ijcseit/V5N6/5615ijcseit01.pdf>
- [31] Nurmurodov J. “Kompyuter ko‘rish bilan tanishish...” *InLibrary*. 2024. <https://inlibrary.uz/index.php/science-research/article/view/35212>