

DRL-VO: Learning to Navigate Through Crowded Dynamic Scenes Using Velocity Obstacles

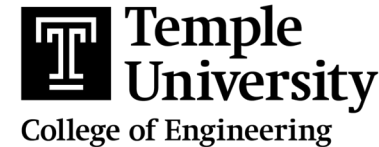
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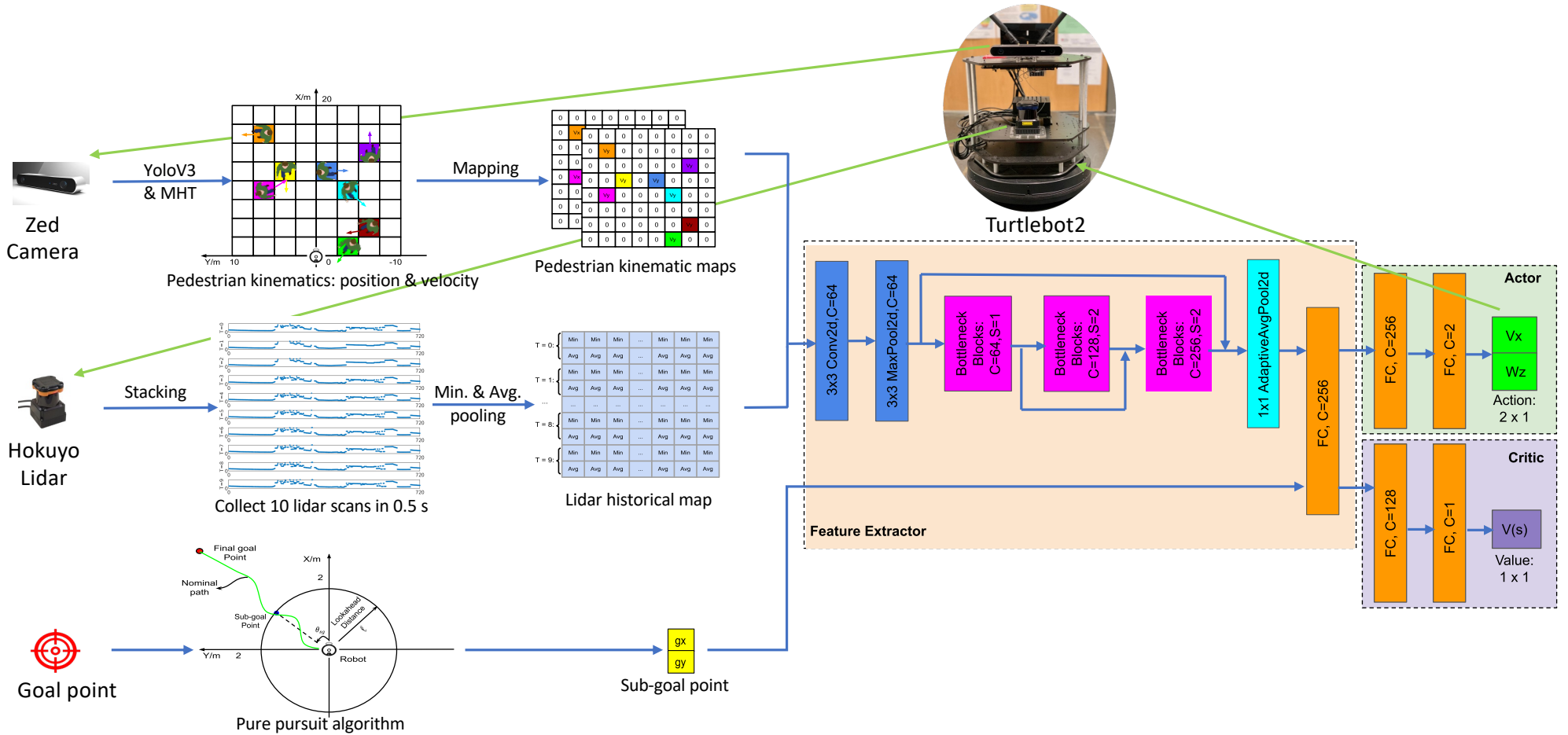
DETROIT

IEEE/RSJ International Conference
on Intelligent Robots and Systems
OCTOBER 1-5, 2023



Mechanical
Engineering

Crowd Aware Control Policy – DRL-VO



Zhanteng Xie and Philip Dames. "DRL-VO: Learning to Navigate Through Crowded Dynamic Scenes Using Velocity Obstacles." *IEEE Transactions on Robotics (T-RO)*. 2023

DRL-VO Policy Training

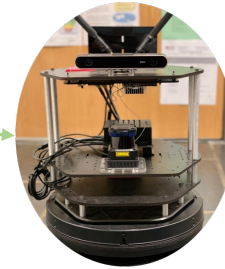
- Multi-objective reward function

$$r^t = r_g^t + r_c^t + r_w^t + r_d^t$$

$$r_g^t = \begin{cases} r_{\text{goal}} & \text{if } \|p_g^t\| < g_m \\ -r_{\text{goal}} & \text{else if } t \geq t_{\text{max}} \\ r_{\text{path}}(\|p_g^{t-1}\| - \|p_g^t\|) & \text{otherwise} \end{cases}$$

$$r_c^t = \begin{cases} r_{\text{collision}} & \text{if } \|p_o^t\| \leq d_r \\ r_{\text{obstacle}}(d_m - \|p_o^t\|) & \text{else if } \|p_o^t\| \leq d_m \\ 0 & \text{otherwise} \end{cases}$$

$$r_w^t = \begin{cases} r_{\text{rotation}}|w_z^t| & \text{if } |w_z^t| > w_m \\ 0 & \text{otherwise} \end{cases}$$



Turtlebot2



Training: single world

- Lobby with 34 Pedestrians
- Proximal policy optimization (PPO) algorithm

Deployment: no fine-tuning

- Different Sim/Real environments
- Different Sim/Real robot models

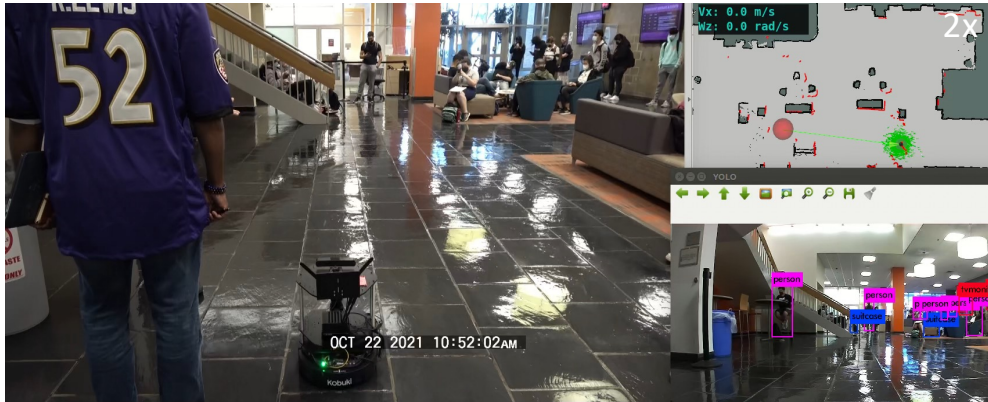
$$r_d^t = r_{\text{angle}}(\theta_m - |\theta_d^t|)$$

- Based on *relative motion*
- Use the **velocity obstacle** model to find the desired heading direction θ_d^t

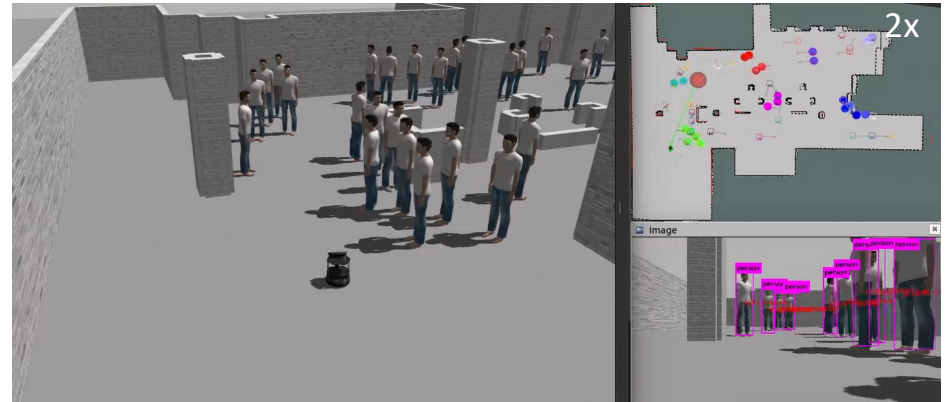
- Collision-free
- Goal oriented

Navigation Results – No Fine-Tuning

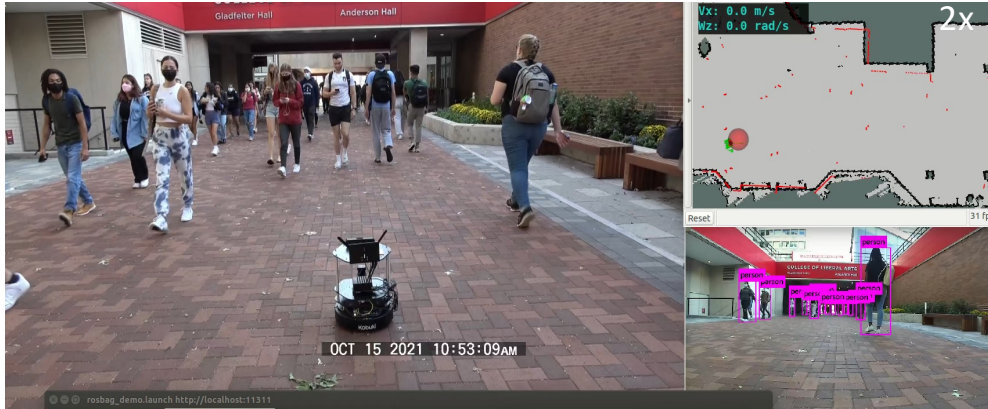
- Indoor lobby



- Simulated lobby



- Outdoor hallway



- BARN challenge in ICRA 2022 (3rd place)



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 - Website: <https://sites.temple.edu/trail/>
 - GitHub: <https://github.com/TempleRAIL>
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