Safety-Prioritized Robust Macroscopic 3D Traffic Flow Optimization Model

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Traffic congestion is increasing every year and causes nearly 100 billion in annual economic costs in the US and Europe each. It causes over 5 million crashes every year in the US with a fatal car accident occurring every 15 minutes. Lancet estimates a global loss of 1.8 trillion to traffic accidents between 2015 and 2030. Solutions to traffic congestion can include expensive infrastructure changes such as public transportation, or adaptive traffic control systems that are unable to handle dynamic, city-wide traffic interactions. Deep learning methods such as CNN and LSTM (Convolutional Neural Network, Long Short-Term Memory Network) have begun to be used in some cities in Asia. However, they involve significant online computation through their predictions, which architectures such as reinforcement learning do not. Currently, there is no city-wide 3D simulation environment studied by reinforcement learning that is physics-informed, which would allow a wide scope of random exploration in a much higher magnitude. To address this, a Unity 3D city environment was used as a training environment for 3 models, CL-PPO (Curriculum Learning Proximal Policy Optimization) and MA-POCA (Multi-Agent Posthumous Credit Assignment). Traffic flow was optimized by dynamically changing speed limits and times of traffic lights with goals of determining the decrease in travel time and number of crashes. Robust Control Theory was applied to ensure safety-first stability and less aggressive behavior. Value loss, policy loss, rewards and value estimate were calculated and analyzed. CL-PPO achieved the best performance and can be used via behavior cloning to train on real-life data to optimize traffic flow, and decrease congestion and crashes, all using safety-first principles.