EGA: An Autonomous Drone Navigation System for Anticipatory Patrols in Complex Forests Using Visual-Depth Reinforcement Learning With CNN in a Hyper-Realistic 3DGS Simulation To Provide Real-time Patrol Guidance by 3D EGA Map

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Every week, at least 2 rangers lose their lives globally due to patrolling in forests. This forces them to face deadly threats from every direction, including traps, wildfires, and fighting with poachers. Drone technology is increasingly used for aerial forest monitoring, but to provide relevant information for anticipating dangers, flying under the tree canopy is crucial. Yet, existing autonomous drone navigation systems fail in complex forests due to the limitations of depth sensor perception and poor adaptability to new environments. Therefore, we propose EGA-AI, a novel reinforcement learning approach for autonomous drone navigation in complex forests. By utilizing a Convolutional Neural Network with Proximal Policy Optimization trained in a realistic 3D Gaussian Splatting simulation with Domain Randomization to improve adaptation. This enables EGA-AI to overcome current limitations by detecting objects that are invisible to depth cameras and providing accurate surrounding contexts, resulting in enhanced decision-making for obstacle avoidance. Additionally, controlled variations in simulation environments enable the model to adapt to unseen forests. Experiments through various forest density levels between 4-8 Stand Diversity Index show that EGA-AI outperforms current methods in both algorithm-based and AI-based methods. It achieves an average success rate and velocity of 96.67% and 3.27 m/s, respectively, in forests with a density of 4-6 SDI. We further integrate our EGA-AI with our drone prototype and develop a 3D forest information map to provide real-time safety patrol guidance that precisely detects and locates incoming dangers. This potentially saves costs, eliminates unpredictable dangers in the forest, and reduces ranger injuries and mortality rates.

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