SafeSkies: Development of an Autonomous System for Detecting and Tracking Unmanned Hot-Air Balloons and Other Aviation Hazards in High-Risk Areas Using Computer Vision

Paschoal Bartoccini, Leonardo (School: Colegio Dante Alighieri)
Schusterschitz, Lara (School: Colegio Dante Alighieri)

The release of unmanned hot-air balloons is a Brazilian cultural tradition that, despite being illegal, poses environmental and socioeconomic threats to the country. Balloons are a major cause of wildfires in protected areas, as they use fire for propulsion and can ignite fires upon landing. Additionally, these balloons pose a risk to national airspace since they cannot be detected by radar and may collide with aircraft. In light of this scenario, this project aims to detect and track balloons in high-risk areas, such as airports and environmental conservation units, by installing on-site cameras integrated with a YOLOv10 computer vision model. The system was trained on 6,073 images of balloons, birds, and airplanes, identifying these objects in images and videos with 94% precision and 92% recall. Next, a prototype consisting of two cameras mounted on pan-tilt units was designed, and a PID-based tracking system was developed to calculate optimal adjustments for each camera. Triangulation was then used to derive an equation for the object's position from the distances between the two cameras and their horizontal and vertical angles. Finally, balloon trajectory predictions were implemented using real-time meteorological databases, the Lyapunov exponent was used to estimate predictability horizons, and an automatic alert system was built to notify authorities upon detection. Current results demonstrate accurate detection and real-time tracking in controlled tests, and indicate that the system could be expanded to identify and track other aviation hazards, such as birds and drones. However, further testing will be conducted to evaluate on-site performance.

Awards Won:
Fourth Award of $600
Association for Computing Machinery: Fourth Award of $500