Senior Honors Research Project
Collision Avoidance System
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Goal:
Build a collision detection and avoidance system capable of real-time execution in both a simulated and physical environment, with the intention of testing on a drone.

Description:
In an era where everything seems to be speeding up and getting busier, collision avoidance is becoming a greater concern. It is a topic that must be approached whether you are an auto manufacturer, air traffic controller, or even private space company. An exploration of collision detection and avoidance systems will be carried out through both the virtual and physical lens in an effort to fully grasp the scope of the field. The integration of code development, robotics, bi-directional communication, analytic geometry, and simulated environments will lead to an in depth project worthy of upholding the "Senior Honors Research Project" title.

The project will follow a high level timeline. First, research into collision detection and avoidance techniques as well as components used (dual-lens camera for depth perception). This will provide the background information and confidence needed to continue with the project. Then concurrent execution of the next two tasks: exploration of simulation practices, tools, and design, and component research for compatibility and solution practicality (ex. camera/object detection systems, precise precision and speed measurements, precise control systems for movement, etc.) will ensue. Note that the latter task will have restrictive limitations based on drone qualities (weight, power, network speed, etc). Furthermore note that I suspect these two tasks alone will take up a large portion of the first semester. The project will then switch focus to creating and training a model upon the simulated environment. This is also the stage where the components must be purchased. The project will become physical, with drone assembly, precision control training, integration with the simulated movement patterns, and interfacing/network connection objectives. Finally testing and modification for performance will be carried out, and the results - live performance visualization, presentation, and possibly a paper - will be finalized.

Intricacies or Challenges I may face:

1. Highly efficient code is necessary so that live-video stream, computation, and returned signals execute fast enough for the drone to avoid the object. Note that this is almost certainly possible because First-Person-View (FPV) drone racers are able

to do this, and we would just be substituting reaction time for one forward propagation through the model (AI Neural Network) and a few other processing objectives. Note that this points to the reality of writing the real-time code in C++.

2. When testing upon a physical drone, time-to-train and risk increases, as well as the likelihood of needing replacement parts. A jig needs to be built to ensure that the project stays costly and the drone doesn't obliterate itself.
3. Interface with the drone for precise control may require custom hardware and software.
4. Precise control through an non-pretrained AI model may be challenging to achieve due to environmental factors and large number of complex parameters (4 brushless motors (pwm), accelerometer and gyroscope).

Confidence:

1. Ability to successfully choose, assemble, and troubleshoot hardware.
2. Model creation, training, customization, and troubleshooting.

Expected Result:

- Simulated visualization of drone avoidance through self-made physics engine
- Real time on-screen video feed with object identification boxes
- Drone avoidance (ex: tossed ball) demonstration

Cost Analysis:

There are numerous online sources stating that it is quite possible to build a FPV drone for under $100 dollars. As I am not an experienced drone builder, my goal is to keep the total budget under $500 (which should include possible AWS instances as well as hardware components). I can cover this if the school doesn't have a fund for projects of this kind.

Involved Topics:

- Building and training machine learning models
    - Collision avoidance model[1]
    - Precise drone control model
- Creating a virtual/simulated environment for avoidance training
- Hardware aspect of building the drone
- Interfacing with the drone for custom control systems
- Image processing, analysis, and object detection. Note that further complexity may exist since the drone must calculate the future trajectory of the object, which includes speed and direction.

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[1] The collision avoidance model will model the avoidance strategy of the drone in a virtual environment

Scaled Up Goal:
A possible advancement could be to compare different types of trained models and control systems used, and analyze performance variations.

Another and more probable advancement would be the use of more sensors such that the drone has near 360 degree sensing, allowing it to *dodge* any collisions as well as any obstacles (walls, other objects, door frames, people, etc). This would be quite useful because it would be able to fly throughout its entire battery life without worry of crashing into anything, not simply anything from a specific direction.