**Objective:** UAV-UGV Docking

- **Objective:** Extend a potential-fields method for docking a small unmanned aerial vehicle (UAV) with an unmanned ground vehicle (UGV) and verify the method through simulation.

**Research Considerations:**
- Use computer vision to direct the UAV
- Make the behavior tunable to environmental and vehicle characteristics
- Must be computationally inexpensive

**Approach:** 3D Extension of 2D Docking Work

- UAV-UGV docking has not been demonstrated using vision.
- Minten, Murphy, Hyams, and Micire (2001) demonstrated low-order computational complexity UGV-UGV docking using potential fields with visual fiducials.
- This 2D work should in theory be extensible to 3D.
- Parameterizing the solution allows control over docking behavior.
- **Potential Fields:** Attractive and tangential with three zones
  - Ballistic Region - Proceed within a certain range of the dock
  - Coercive Zone - Transition from the ballistic region to the approach zone
  - Approach Zone - Gently guide the vehicle into contact with the dock
- **Simulation Parameters:** Starting locations, field sizes, field strengths, field tapering, landing pad rotation, approach cone aperture

**Challenge:** Correct Tangential Vector

- Problem:
  - There are infinitely many tangential vectors to another vector (unit normal vector definition of a plane).
  - How is the correct vector chosen from among these?

- Solution:
  - Use the attractive vector to define one plane (provides an infinite number of tangential vectors).
  - Define the vector of dock orientation as a vector passing through the dock and the pink orientation sphere shown.
  - Use this vector crossed with the attractive vector to define another plane intersecting the original plane.
  - The vector defined by the intersecting planes is the correct tangential vector at that test point.

**Testing: SARGE Simulation**

- **SARGE Information:**
  - SARGE stands for Search and Rescue Game Environment.
  - SARGE is essentially a video game used for training search and rescue personnel and simulating robot behavior.

- **Uses for SARGE:**
  - It is accurate enough for the training to translate to the physical world.
  - It provides a realistic visual atmosphere to facilitate the viewing of simulations.

- **Implementation of Simulation:**
  - Used Unity game development software
  - Used pre-rendered SARGE models for robots
  - Defined underlying robot behavior using JavaScript

- **Test Cases:**
  - 48 total test runs
  - Divide slider bar location into two categories: right of center or left of center
  - Produces 32 distinct start locations to test
  - Produces 16 potential field parameter variations to test

**Contributions and Acknowledgements**

- **Contributions:**
  - First vision-based docking algorithm for UAV-UGV docking
  - Solves tangential field problem in extending potential fields from 2D to 3D
  - Will be used for physical trials in the fall

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**Sources**