A Haptic Interface with Adjustable Feedback for Unmanned Aerial Vehicles (UAVs) –Model, Control, and Test

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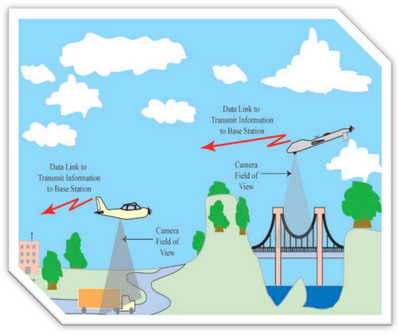
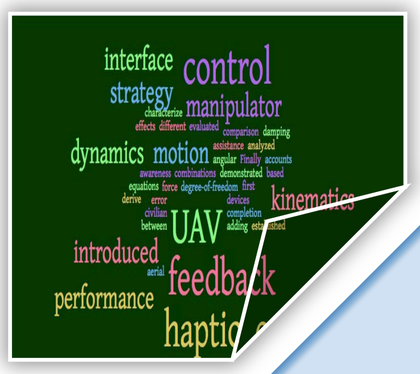
Introduction

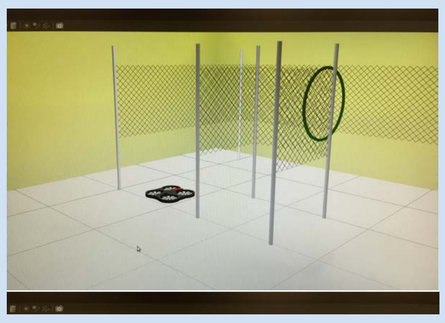


- **UAV (Unmanned Aerial Vehicle) applications**
  - **–Environmental monitoring**
  - **–Agricultural chemical spraying**
  - **–Land management**
  - **–Merchandise delivery**

- **Haptic feedback**
  - **–Interprets the operator commands**
  - **–Regulates the vehicle's dynamics**
  - **–Feed states back for enhanced UAV performance**

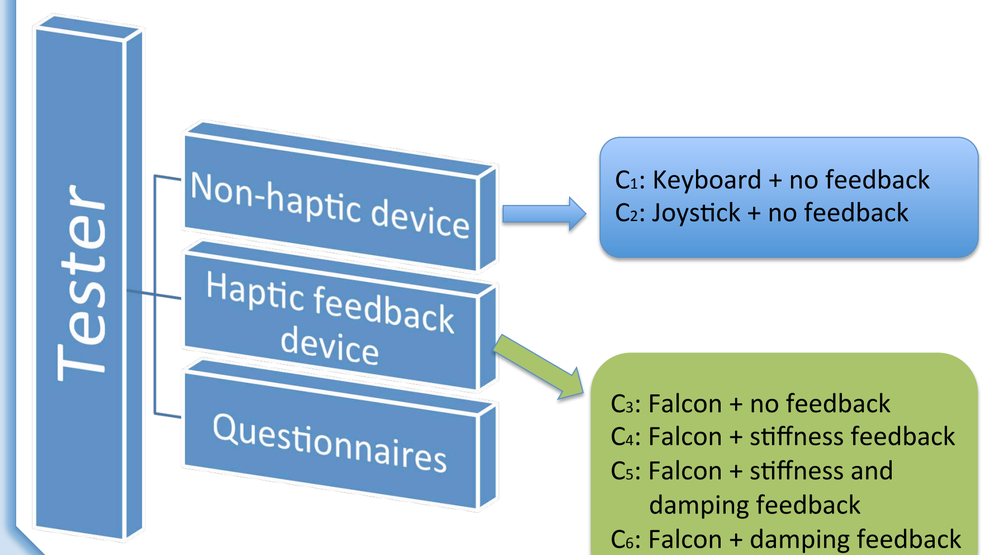


To increase awareness for operators, a three degree-of-freedom haptic interface is introduced to provide helpful assistance for UAV motion control.

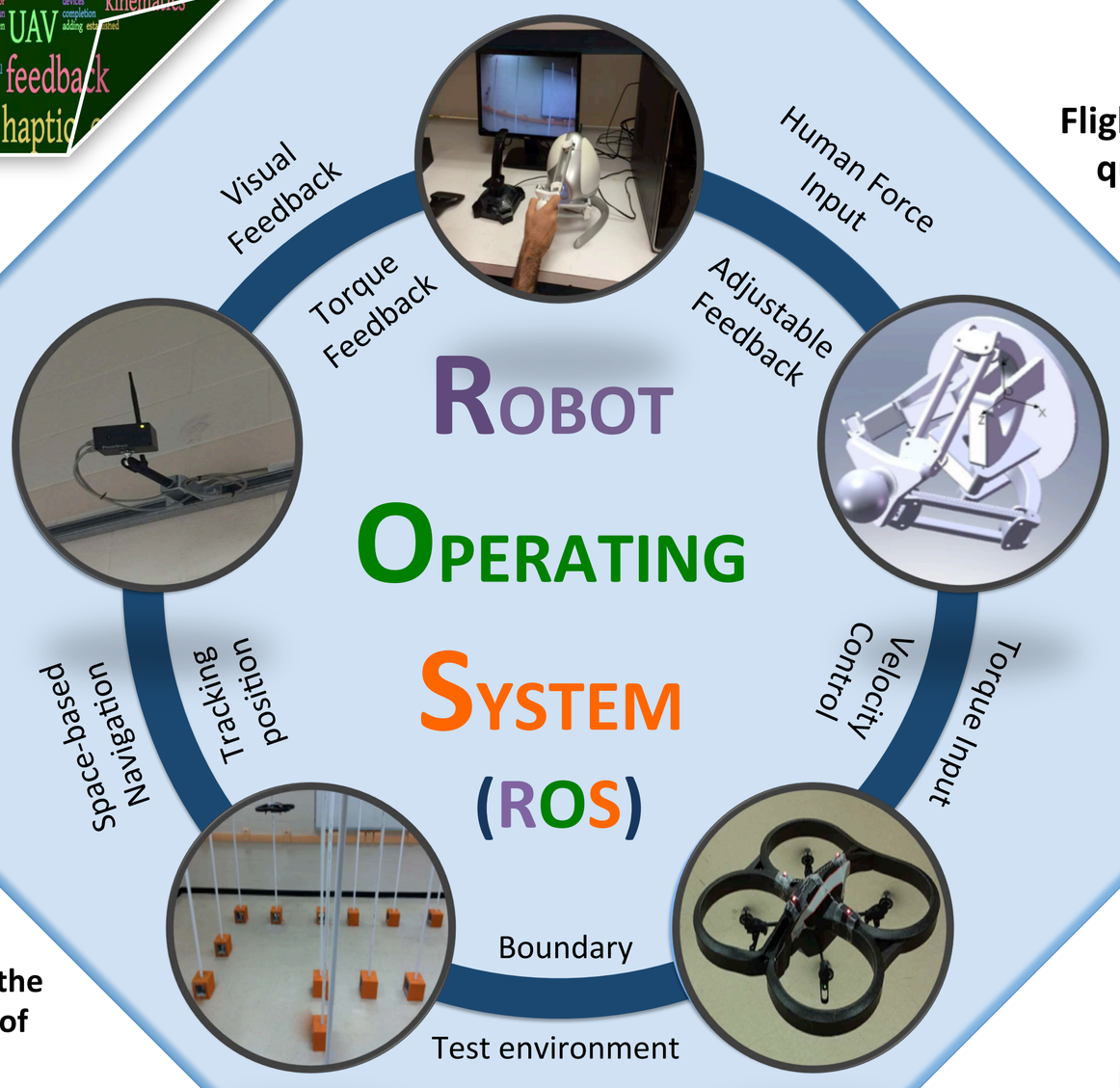


Flight simulation environment

How It Works



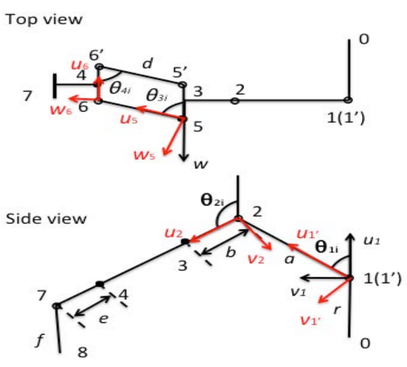
Flight paths are recorded and questionnaires are subjectively evaluated in C1 to C6 condition. Error deviation and test completion time are considered as two human performance measures.



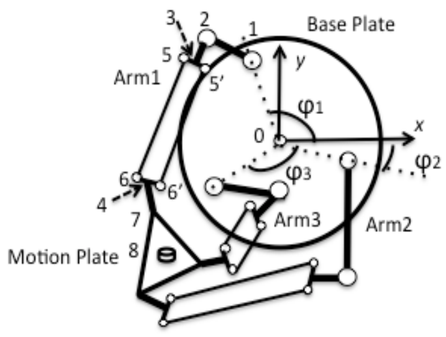
Haptic Device Model

Mathematical model of haptic device can provide relationship between end point position and motor angle motion.

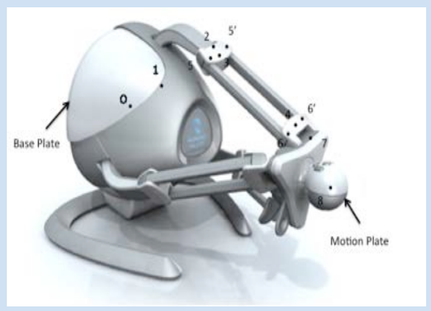
A kinematic model is established to derive the Jacobian matrix and the inverse kinematics of the manipulator to solve positioning and velocities problems.



Depiction of the joint angles and link lengths for leg *i*, using a side view (left image) and a top view (right image).

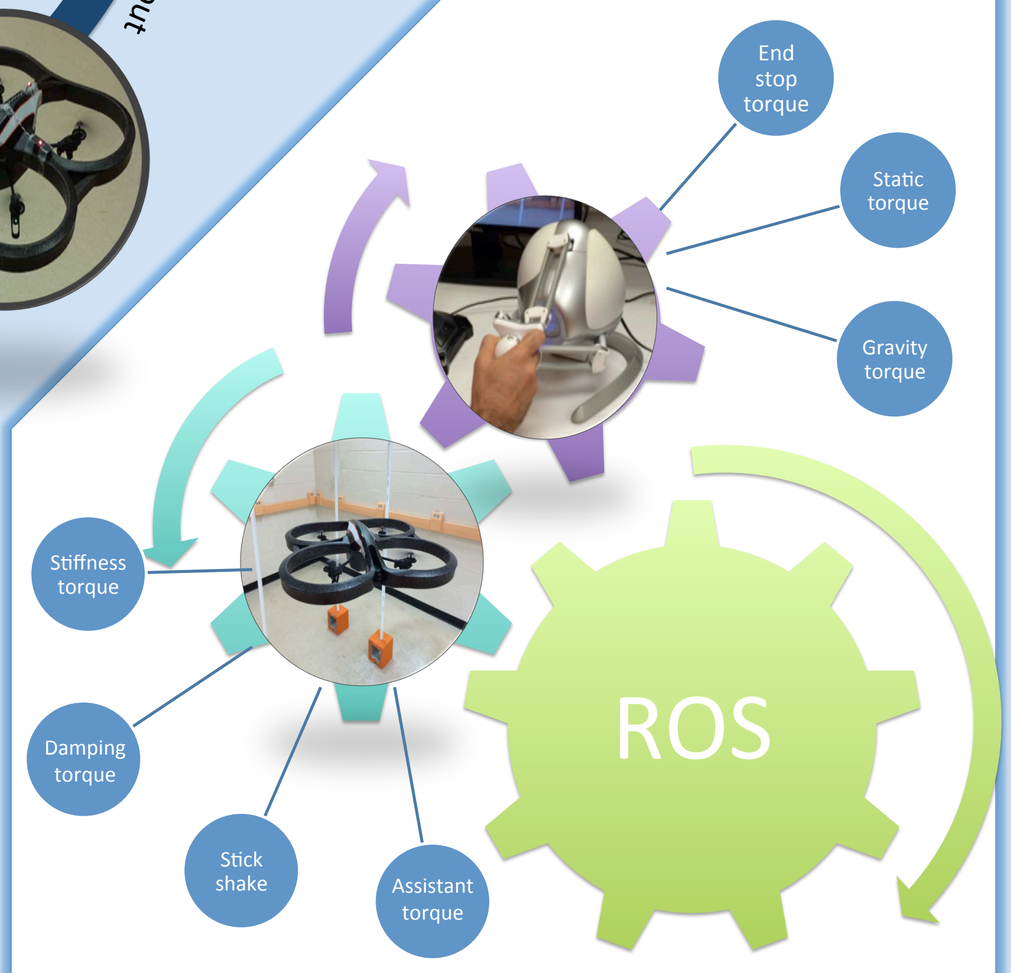


Kinematic representation of the Falcon haptic device with three arms along with the base and motion plates.



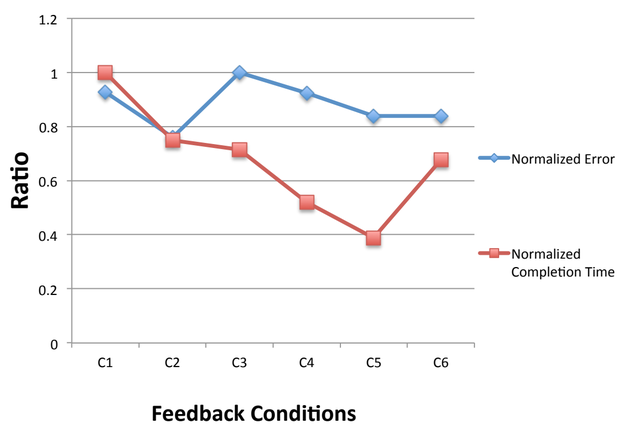
Novint Falcon haptic device for three-DOF with multiple links interfaced to servo-motors for force feedback.

Adjustable Feedback

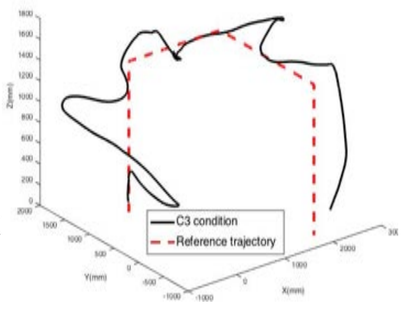


Results

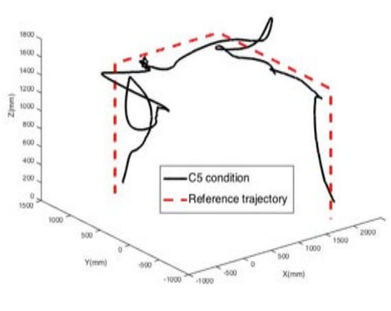
The normalized position error and completion time plots are presented. The optimum feedback condition has the lowest ratio.



Falcon with stiffness and damping feedback, *C5*, offers the best tradeoff in terms of error and completion time performance. The joystick *C2* is optimized to decrease the position error but sacrificed with completion time.



UAV flight path operation versus reference trajectory – stiffness and damping feedback, C5



UAV flight path operation versus reference trajectory - no feedback, C3

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