Image Processing for Data Acquisition and Machine Learning of Helicopter Flight Dynamics

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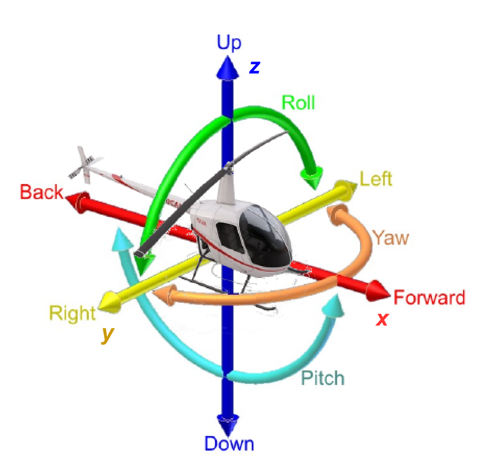
start something big

Introduction

Learning to fly a full-sized helicopter is a complex iterative process of mapping interdependent causes to interdependent effects via inputs to outputs in real time in a wildly dynamic, messy, and unforgiving environment. This work presents a prototype system for acquiring otherwise inaccessible data from the controls, instruments, and flight dynamics of a Robinson R22 helicopter with an array of cameras and sensors and then processing these images into corresponding numerical form for later use in a machine learning project.

Inputs

The physical state of the helicopter is defined by its position in three-dimensional space on the *x*, *y*, and *z* axes and an attitude in *roll*, *pitch*, and *yaw* respectively about them. *Time* is also used to compute the speed (change in state) and acceleration (change in speed) of each.



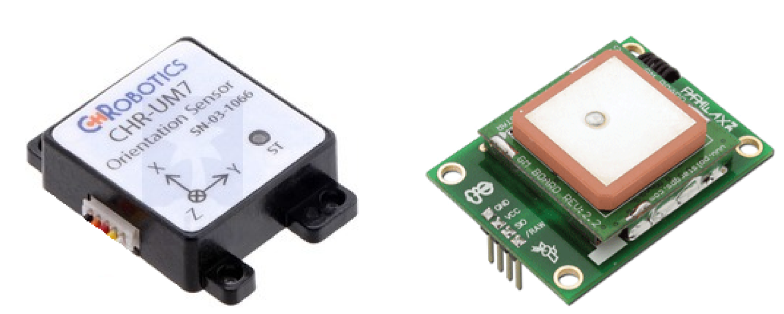
Three primary controls change the states. The *cyclic pitch control* (a) is a joystick whose movement forward/backward affects pitch, and sideways, roll. The *collective pitch control* (b) is a lever that changes the amount of thrust from the main rotor to affect the *z* position (altitude), as well as *x* and *y*. The *antitorque pedals* (c) travel in a forward/backward arc to change the amount of thrust in the tail rotor to affect yaw.

Outputs

Four instruments indicate primary information about the helicopter to the pilot:

a. *altimeter*: altitude above sea level
b. *airspeed indicator*: speed through the air
c. *vertical speed indicator*: change in altitude in feet per minute
d. *manifold pressure gauge*: amount of power being demanded from the engine

An attitude heading reference system (AHRS) for position and attitude and a GPS receiver for latitude and longitude augment the visual information because there are no comparable instruments for the pilot.



Architecture

The hardware and software architecture combines the AHRS and GPS with up to six tiny cameras positioned throughout the cockpit. A Beaglebone Black single-board computer coordinates all actions and records data.

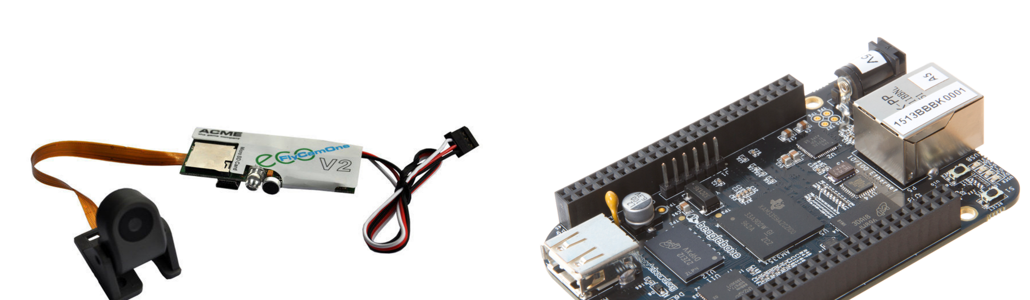
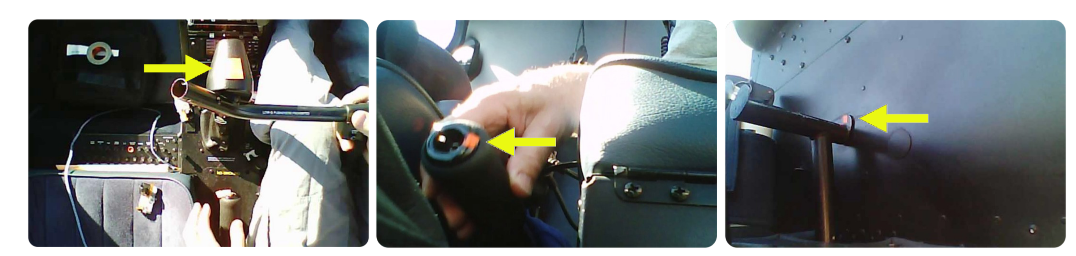


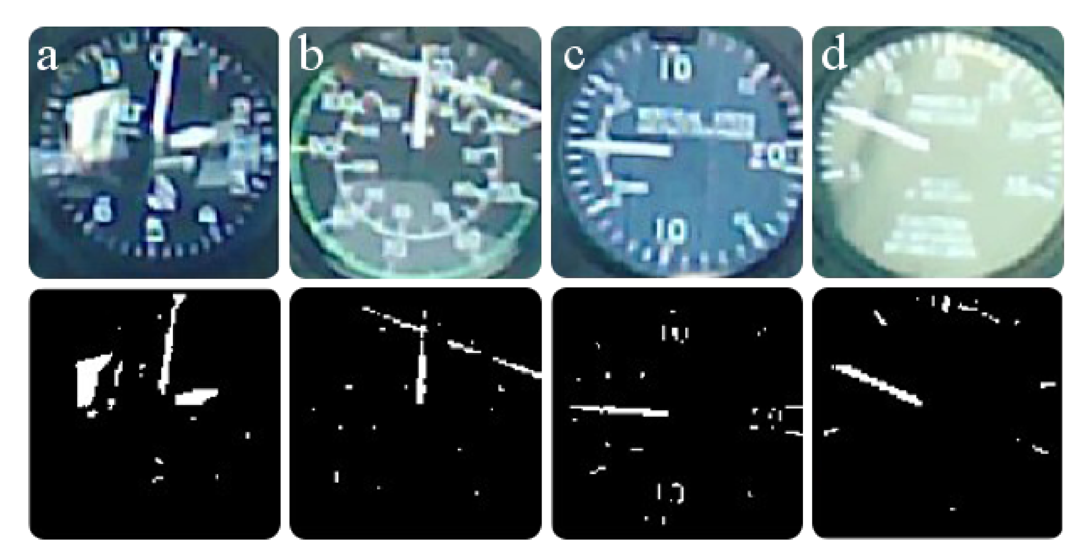
Image Processing

One camera captures the movement of each control. Image processing determines its position by tracking an orange reference sticker and translating the position to a numerical input.



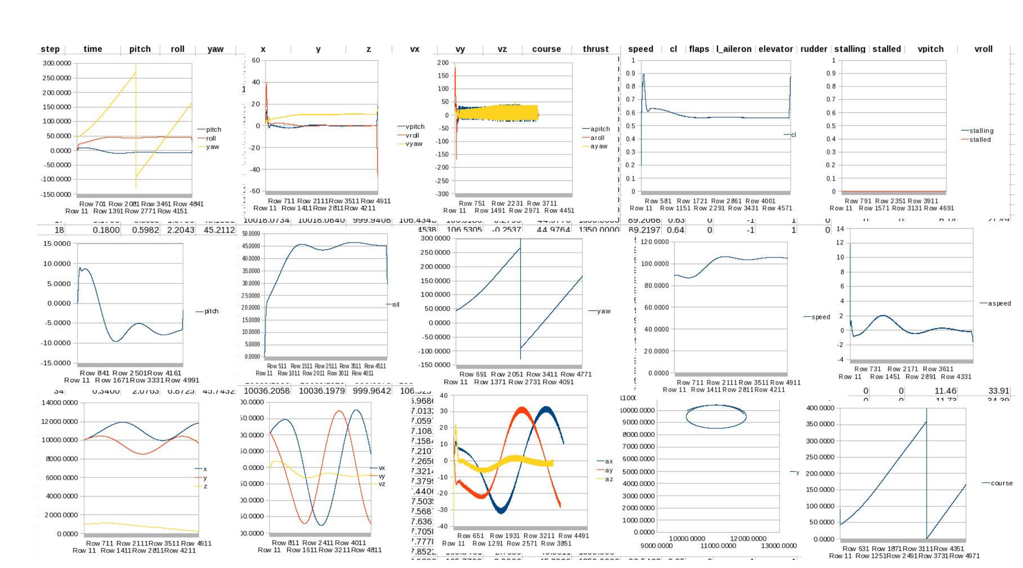
Cyclic Collective Pedals

The instruments are sealed and cannot use stickers. Instead, the image processing isolates the features that best identify the needles, converts the results to angles, and translates them into numerical outputs.



Results

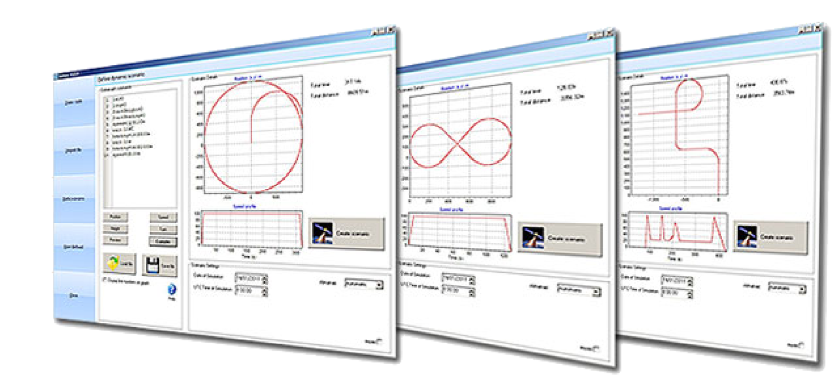
Presenting the numerical values as Excel graphs provides visual insight into the relationships between inputs and outputs.



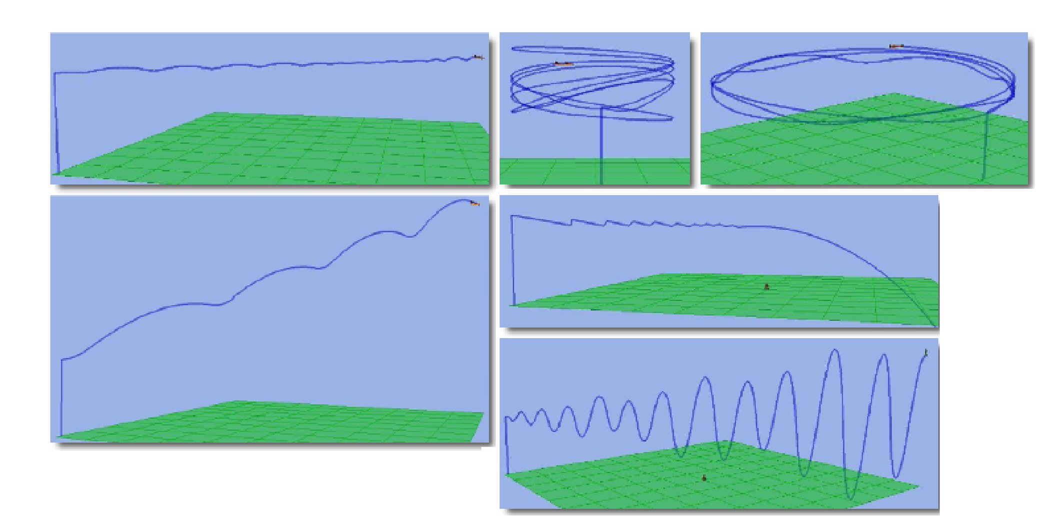
Results

The results are much easier to evaluate when visualized from an internal view on the instrument panel of a virtual cockpit:

Two-dimensional representations depict various flight maneuvers:



Animated, interactive three-dimensional representations provide a wealth of insight:



Integration with Google Earth connects all the data from a real-world bird's eye perspective:

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