G.E.M.I.N.I.

Gyroscopic ElectroMotive Inertial Navigation Initiative

Guidance System
Operating Manual

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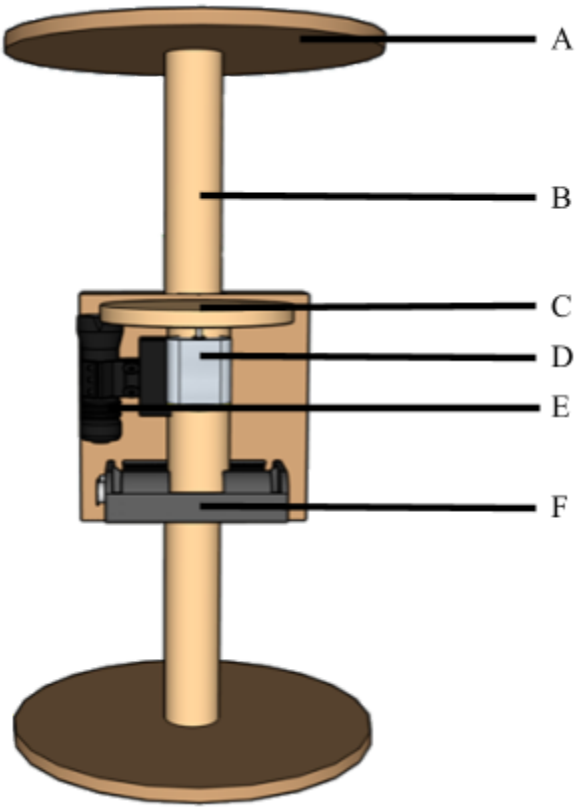
Diagrams

Figure 1: GYROSCOPE FRONT VIEW



A - Top/Bottom disks: Attached to the sphere, does not allow movement except in the middle axle, where there is a bearing on both disks.

B - Middle axle: Allows for the rotation of the middle panel on the xz plane, secured in place with a bearing.

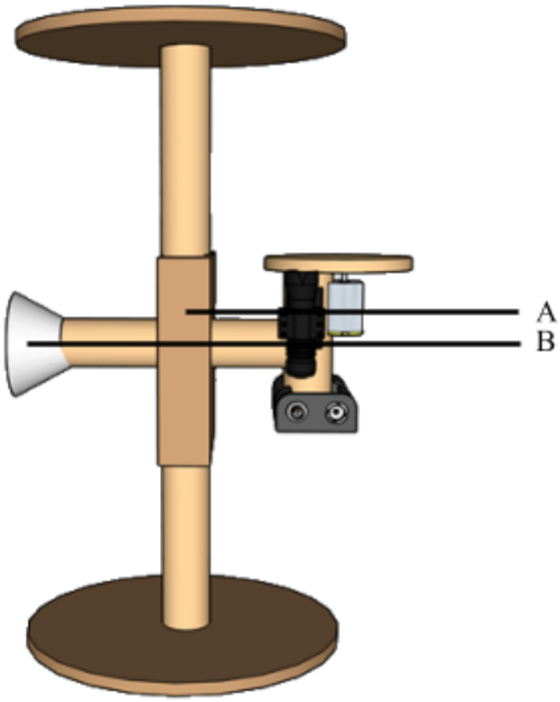
C - Rotor: Spins by a constant motor (D) and by rotational inertia and the conservation of angular momentum, stays in place, holding the reference direction.

D - DC motor: Motor is attached to another axle, not shown in this view, parallel to the axle. The motors used are rated for 3-6 V.

E - LED: Tintri Model LM2 (max output 5 milliwatts) was used in the angle detection procedure, stays parallel to the outer axle, regardless of orientation. Placed in a way that is not obstructed

F - Battery case: Contains two AA 1.5 V batteries in series to power the motor. The LED has its own dedicated battery source contained inside of the casing. Placed at the end of the outer axle to balance the center of mass.

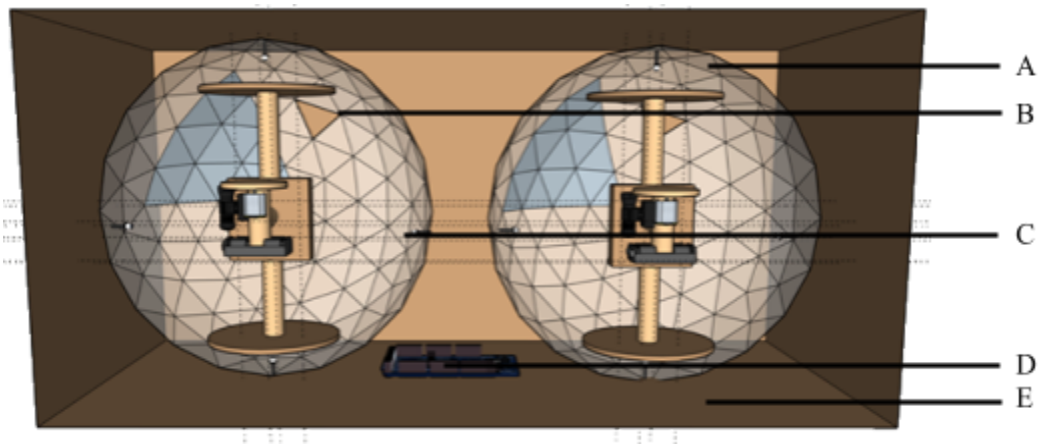
Fig 2: GYROSCOPE LEFT VIEW



A - Central panel: Holds the horizontal axle in place, acts as a support for the two axles. It contains the central bearing which allows for rotation in the yz plane.

B - Counterweight: A truncated cone made of clay is attached to the opposite end of the horizontal axle to balance the contraption on the right side.

Figure 3: GYROSCOPE HOUSING CROSSSECTION



A - Pollux: Named after one of the two Gemini twins from Greek mythology. Reinforced encasing for the gyroscope structure. It also acts as the detection sphere where the LED is aimed against. The second sphere is named Castor.

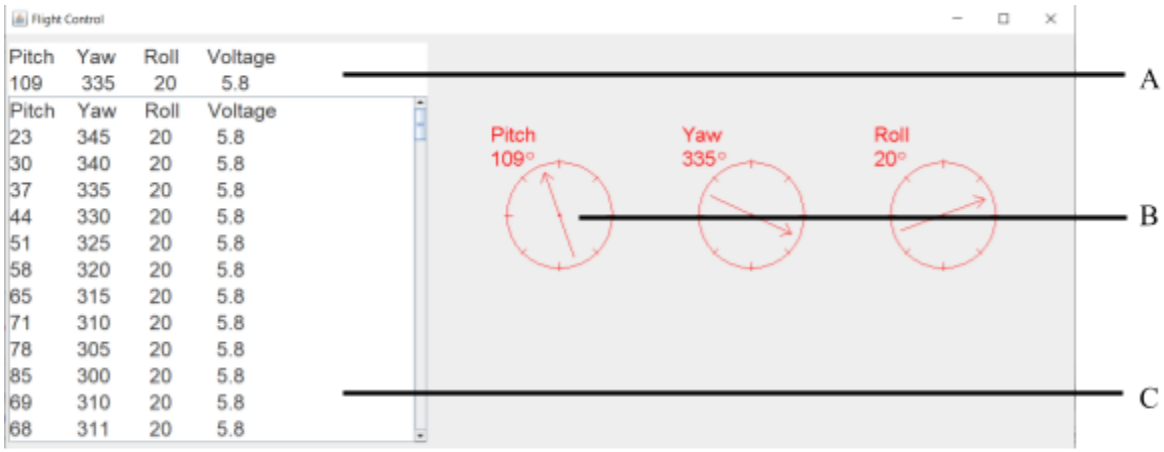
B - Castor: The second twin after Pollox, a Gemini twin from Greek mythology. Read its properties in the A part above.

C - Photodiodes: The foundation of the sensing system, the photodiodes detect the intensity of light from the LED and relay the information to the Arduino. Each sphere has four BPW34 (430-1100 nm) photodiodes arranged in a tetrahedron around the origin, i.e. the central bearing.

D - Arduino: Specifically the Arduino Mega 2560, this onboard communication device receives the signals from the photodiode and relays them a user computer

E - Outer housing: The reinforced case for the two spheres and the Arduino device. Velcro is used so that the internal components can be accessed easily, for repair, maintenance, and running the spaceship.

Figure 4: GUI INTERFACE



A - Current values: At the top of the Captain's log is the current value of the pitch, yaw, roll, and voltage status. The angles are shown in degrees while the voltage is displayed in volts.

B - Pitch, Yaw, and Roll radars: The three radars on the right-hand slide of the flight control panel provide an intuitive sense of the orientation of the spaceship.

C - Raw data: Tracks the four parameters as the program and the gyroscopes run to allow for convenient comparison. The time delay between each output is one second.

Installation Instructions

HARDWARE

1. Open one of the boxes
    - The spheres should reside within each of the cubic cardboard boxes. If not, place the spheres inside after completing up to step 5. To do so, slot the sphere into the middle square section so that the sphere system sits on its base. The sides of the cube are folded up to enclose the sphere inside and then sealed. Ensure that, when upside-down, the box doesn't not open and drop the sphere out.
2. Open up one of the spheres
    - The sphere consists of two halves with Velcro to hold them together. It is meant to be able to come apart easily, so DO NOT apply excessive force.
3. Switch the light and the motor on
    - The light is the second button down on the red flashlight casing, which can be found as part E in Fig 1.
    - The motor switch is on the battery case. This can be found in part F in Fig 1. on page 5. The On/Off switch may require some searching for.
4. Close sphere and box
    - Ensure that the two halves of the sphere are well-sealed, allowing little to no light to penetrate into and out of the space inside the spherical shell.
    - Ensure that the box properly holds the sphere, so that the device can withstand being flipped upside-down without comprise.
    - Ensure the wires are attached and not bent in abnormal or concerning ways
5. Repeat previous with second box and sphere.
    - When initiating the motors, try to begin the direction of the rotors perpendicular to each other. This will provide the best opportunity for full detection along all three axes.
6. Allow for both to stop moving
    - Movement and motion may cause the gyroscopes to have a small initial spin, as well as the transient phase as the motor gains revolution speed up to the maximum. Ensure that the rotors have established a direction by allowing some time. 5 seconds or so is suggested.
7. Connect to laptop
    - Press run
    - For setup, see the software setup section.

8. Run the gyroscope
9. Move slowly for best results
    - Rapid movements may cause parts pf the gyroscope to gain unwanted momentum and swing past where they are meant to point, which would then require a short amount of time to re-establish the "correct" direction, or simply acquire a new one. Either of these is undesirable for accuracy, and consecutive rapid motions can exacerbate error.

SOFTWARE

1. Follow the steps above to ensure that each of the electrical components has a proper power supply
    - This includes the Adruino, motors and LEDs. Double-check the different battery packs and individual batteries to locate any faults before the device is used
2. Download the required zip file
    - Uncompress the Adruino and the Java code from the package. Open both of them in their respective workspaces and keep in mind that certain functionalities are only possible in the newest software snapshots of the external libraries and coding languages.
3. Find the HC05 Bluetooth chip
    - Using the "BluetoothSearch.java" file, use it to locate the external Bluetooth chip in the spaceship. This is discoverable under the name "DSD Tech HC-05." Once the Bluetooth ID is obtained continue to the next step.
4. Substitute the found Bluetooth ID into the main "HC05.java" file
    - The source code is provided so this change should not be too burdensome. Find the place to swap out Bluetooth ID in the documented code and replace it with the ID in an identical format.
5. Run the program
    - Keep in mind that Mac OS X does not support the current library: two changes are required to run this on a Mac computer. First, a 32-bit of a Java workspace is required such as Keplar Eclipse. Next, the build path of the Bluetooth needs to be modified to point to a previous version of Mac OS that supports Bluetooth.
    - Another common problem is the "Bluecove library not found." Ensure that your computer software and the Bluecove external libraries are compatible. Usually, downloading the latest snapshot, 2.1.1, solves this issue.
6. Observe the various parameters on the Flight Control GUI
    - Figure 4 explains each component in detail

Maintenance

VERIFICATION INSTRUCTIONS

- Photodiode
  - If the guidance system no longer works, one possible reason could be due to the individual photodiodes. In order to check, use the “mainphotoreading.inl” file, which displays the brightness readings from the diodes. Proceed to use a light source of any type, the flashlight on the gyroscope, or another of your choice. Subject the photodiode to both direct light and complete darkness and observe whether the full range of values is feasible: from 0 to 1023.
- Motor
  - If the disc is not spinning, perhaps the motor is not working.
- Flashlight
  - If the light is not on inside the sphere, then the issues are with the flashlight.
- Battery
  - Check the voltage level to see if it is too low, which can cause the electronic parts to not operate. Simply replace these with new batteries.

REPAIR INSTRUCTIONS

- Wiring connections
  - Before beginning to attempt to fix or replace parts, first, check the associated wires to ascertain that they are all connected and that these connections are secure.
- Photodiodes
  - Ensure that nothing is covering the sensor of the photodiode.
  - To replace, detach the broken photodiode at the first wire connection and remove it from the inside of the sphere. Obtain a photodiode rated for visible light (about 400 to 750 nm) and attach wires to either side. Slot the new photodiode through the hole and attach it to the wires. It is possible that the photodiode is connected the wrong way around, as there is a “right” direction. Simply flip the wire connections if the values are abnormally low. This will have to be tested by the program.
- Motor
  - Ensure that the motor is able to spin the disc without impedance from external sources.

  - To replace, unclip the wires attached to the motors and attach a new one in the same spot. Pull the disc off the broken motor and use hot glue, superglue, or another alternative to reattach. Ensure that the disc is able to turn without rubbing against anything, especially the motor itself, wires, or the spherical shell. Test by switching the battery on.
- Flashlight
  - Remove the flashlight while noting down what angle the light was pointing at initially.
  - Change the battery in the flashlight and test again.
  - To replace, obtain a new flashlight of similar spread and intensity and install directed in a similar angle to the original flashlight.
  - Ensure that the path of the light is not significantly obstructed and that an approximately radially symmetrical light hits the surface of the sphere.
- Spherical shell
  - If there is a small puncture of a gash, try simply taping over it a few times over.
  - For larger breaks, a paper mache piece of paper or newspaper may be necessary to cover this, or an all-new sphere altogether. The diameter of the sphere is 24 cm, about the size of a basketball.