Robotic Normality Sensor

06

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Problem Statement

A robot normality sensor system is needed for an industrial robot that drills rivet holes for airplane manufacturing.

System Requirements

- Measure the two angles between a robot end effector and the work surface.
- Display pitch & yaw in less than a second.
- 0.5° angular resolution or better.
- Sensor itself must be small (< 3" x 3" x 6").
- Various airplane surfaces (aluminum, graphite, steel, composites, alloys).

Design Approach

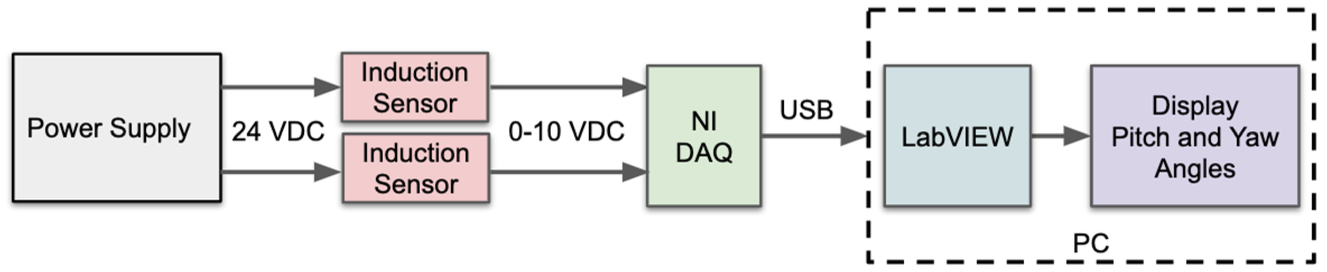

Fig. 1: System Block Diagram.

- We have power supplied to our two analog induction sensors.
- The sensors will take displacement readings and produce analog voltage signals which are then digitized using a data acquisition device (NI USB-6001).
- These digitized signals are then interpreted and processed through LabVIEW.
- The final results from LabVIEW is the pitch and yaw angles of a work surface relative to the sensors.

Physical System Design

- Spherical Bearing: Serves as base of sensor structure. This component is pressed up against surface and the pressure of contact will cause the inner ring of the bearing to rotate.
- Attached to the outer ring of the bearing is a support to hold a steel plate. The steel plate is necessary because the sensors only respond with ferrous metals.
- Attached to the inner ring of the bearing is a support for the sensors. The two holes in this component are where the sensors will be placed.
- The sensors will take displacement readings down to the steel plate and determine the pitch and yaw angles of rotation they make during contact with a work surface.

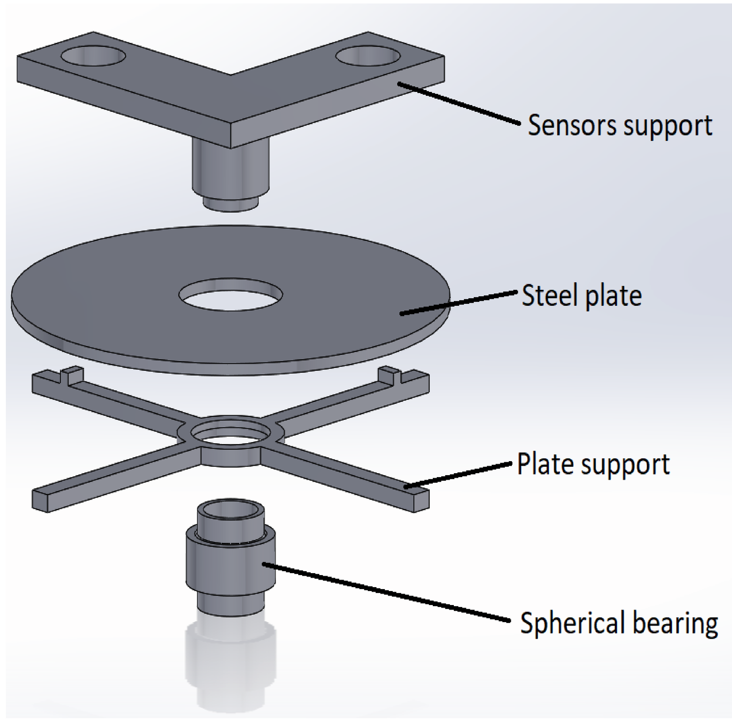

Fig. 2: Exploded Assembly of Sensor System.

Component Selection

- The inductance sensor was chosen because it is a non-contact sensor and had the best resolution to price ratio.
- The spherical bearing was chosen because it allows for independent rotation of two surfaces which was needed to simulate airplane manufacturing conditions.

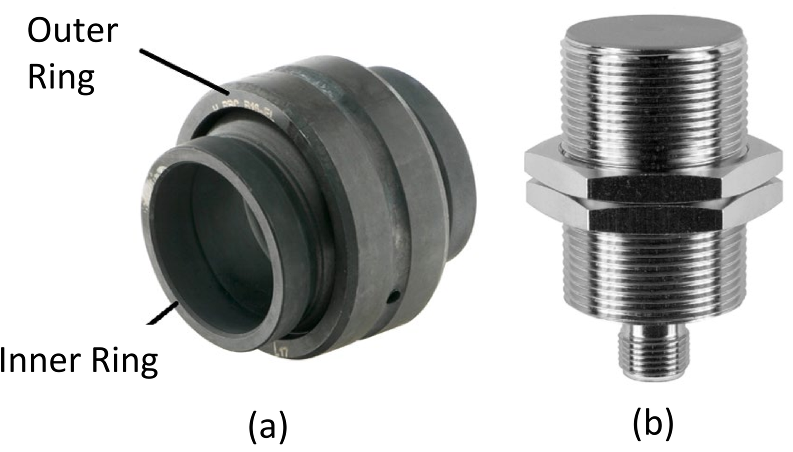

Fig. 3: a) Spherical bearing[1], b) Induction sensor[2].

LabVIEW Interface

- Angle Calculator allows user to manually double check sensor angle outputs with trigonometry.
- Sensor Angle Calculator outputs the pitch and yaw as seen from the inductance sensors with trigonometry.
- Calibration buttons to calibrate the pitch and yaw sensors independently.
- Green light to indicate when a change of greater than half a degree has happened in either the pitch or yaw.

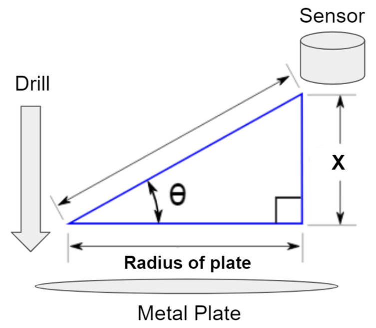

Fig. 4: Sensor Placement and Angle Calculation.

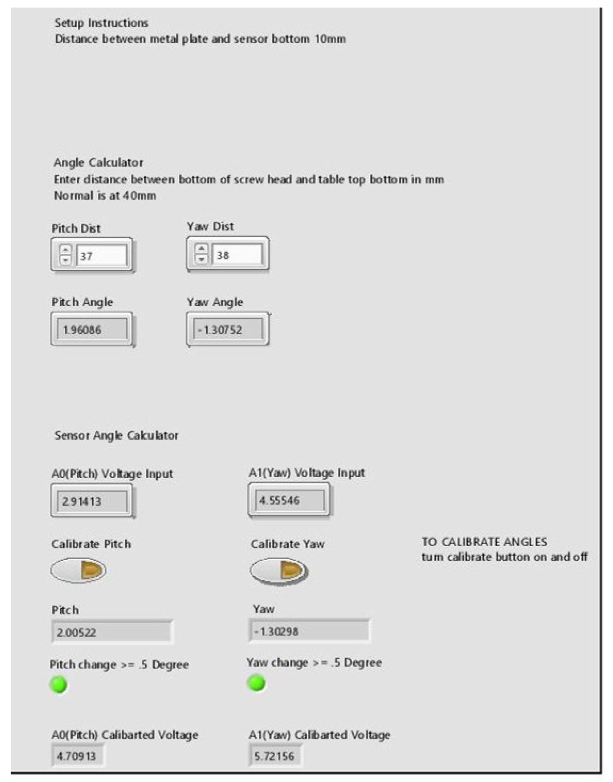

Fig. 5: LabVIEW Interface.

Testing

- Our first test setup included two inductance sensors 90 degrees away from each other, measuring the pitch and yaw of a steel plate.
- With a rotating pitch axis we were able to test the system's ability to convert the analog output voltages of the sensors to degrees.
- Testing shows our system has resolution to less than half a degree and can output real time pitch and yaw readings.

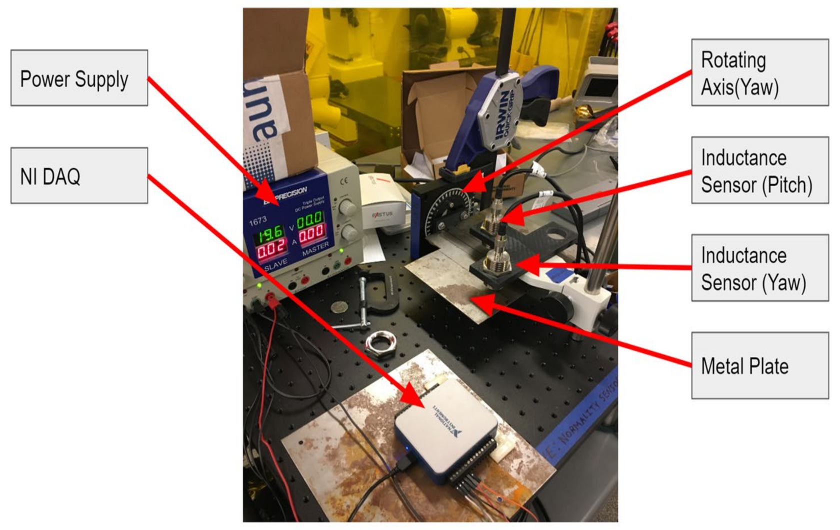

Fig. 6: Initial Test Setup.

Results

- Our final testing system allows independent pitch and yaw axis rotation from adjustable screws below the steel plate. The adjustable screws allow for fine axis rotation.
- The developed system outputs the pitch and yaw in real time.
- The system operates independent of work surface type.
- Expense for project is 60% under budget.
- Support of sensors and bearing was 3D printed at the UW BARC lab.
- Simple trigonometry was used to find the pitch and yaw angles.
- Final prototype angular resolution: 0.1°
- Using only two sensors, calibration is needed to identify at what point the plate is normal to both sensors.
- By using four sensors, this calibration could be disregarded.

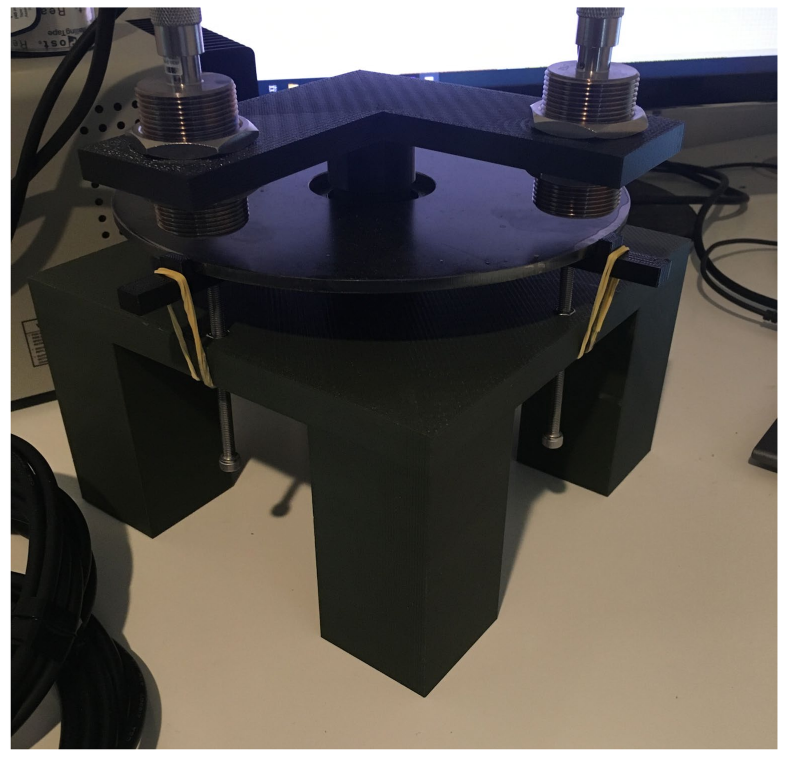

Fig.7: Final Prototype.

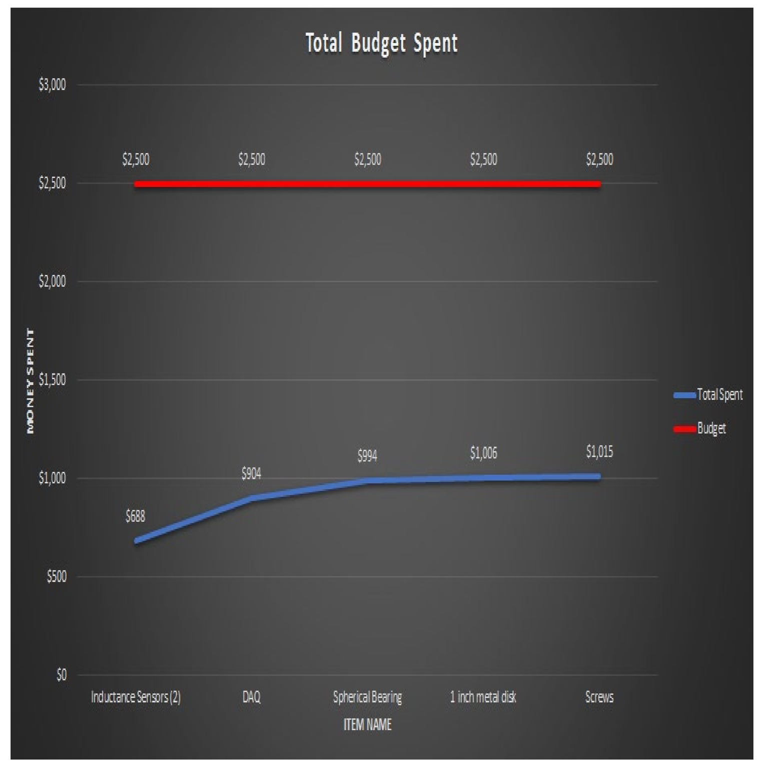

Fig.8: Budget Report Graph.

Future Work, References, and Acknowledgments

- Improve the design structure so it can be mounted to an ABB robot.
- Replace 3D printed parts with machined metal parts.
- Integrate LabVIEW output to ABB robot.
- Program ABB robot to reorient the end effector in response to sensor data.
- Add features like chip blow-off, vacuum for dust collection, and cutter lubrication.

[1] RBC Bearings. http://rbcbearings.com/literature/pdfs/SPB052010.pdf
[2] Baumer. https://www.baumer.com/medias/__secure__/Baumer_IR30.D18L-F60.UA1E.7BO_EN_20191202_DS.pdf?mediaPK=8989166567454.

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