ISU Senior Design - December 2013

Gyroscopic Roller Alignment Tool

Project Plan

Team Dec13-05
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1 EXECUTIVE SUMMARY

As machine-based construction and assembly of products remain a driving component of industry, the maintenance and reliable performance of these machines is of the utmost importance. Through a partnership with PowerFilm Incorporated, our senior design team will create a functional product to assist with machine calibration. This project will focus on the product's accuracy, ease of use, and portability.

This design team will consist of two Computer Engineering students and one Electrical Engineering student from Iowa State University. This team will research, design, construct and test a feasible, low-cost solution to meet or exceed all requirements for this tool as established by PowerFilm, Inc.

This project plan will aim to summarize the design process of the gyroscopic roller alignment tool. The document will also contain a formal statement of the problem and its resolution, the tool's intended use, system descriptions, and a record of project management.

2 PROBLEM STATEMENT

A tool is needed to align rollers, using gyroscopes, in a machine that processes long rolls of film. The film starts on a single roller and is then sent through a series of rollers during which various substances are deposited on it to create an end product. Due to the number of rollers in the system and the delicacy of the final product the rollers in the machine need to be aligned such that there is a minimal amount of roller misalignment.

3 PROPOSED SOLUTION

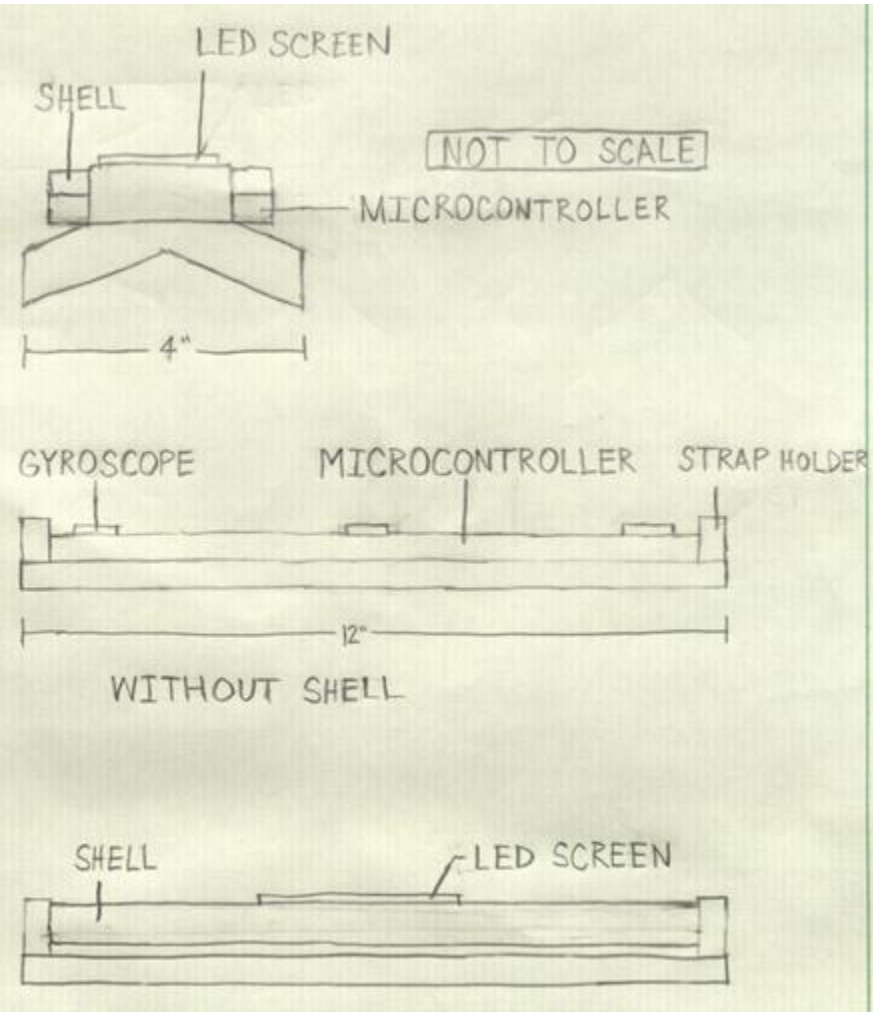
The tool will work such that it will be placed on a master roller and zeroed to that alignment. It will then be subsequently moved to each additional roller in the line and will display how the orientation of the gyroscopes has changed due to the alignment differences between the master roller and the current roller.

It will display a live feed on an LCD screen and also communicate with a PC interface via a USB connection. There will be buttons on the tool so that it can be used independently of the computer.

4 INTENDED USERS

The primary user base for this product will be our client, PowerFilm, Inc. This tool will be used to align rollers used in their production equipment.

5 DESIGN SKETCHES



6 SYSTEM DESCRIPTION

6.1 Operating Environment

The gyroscopic roller alignment tool is designed for use with rollers in PowerFilm's production machinery. As such, it will be used exclusively in an enclosed, controlled warehouse environment. Due to the very nature of its purpose, this tool will be used in close proximity to industrial equipment.

6.2 User Interface Description

The user of this tool will be able to recieve information in two ways. The primary and most detailed method will be via a computer-based client program. This program will be able to display the gyroscopes' output in real-time as well as capture and graph the current device output in order to compare the position of multiple rollers within a single machine. The other method is through a simple 16-digit LCD which will only output the device's current reading of pitch and yaw, for portable use without dependency on the client program.

6.3 Functional Requirements

6.3.1 Attachment

The device will use a triangular base and straps to securely attach itself to each roller in alignment with the axes of rotation.

6.3.1.1 These straps will be adjustable to accommodate different roller sizes and rule-marked for accurate alignment.

6.3.2 Circuitry Placement

The device's base will have a flat top on which will be mounted the hardware components of the tool.

6.3.2.1 The hardware components will be covered by a plastic shell for appearance and protection.

6.3.3 Circuit Components

As specified by the client the tool must use gyroscopes to determine correct alignment of rollers.

6.4 Non-Functional Requirements

6.4.1 Dimensions

The device will be no more than twelve inches long, approximately four inches tall and four inches wide.

6.4.2 Portability

Critical functions of the device (i.e. gyroscope readout) will be usable separately from the PC user interface.

6.4.3 Communication

The device will use SPI to communicate between all on-board systems and a USB connection to send information to a PC interface.

6.5 Constraints

- Must be less than 14 inches long.
- Cost less than $500 to construct.
- Cannot use line of sight.
- Accurate to .8 degrees over 15 rollers.
- Must work independently of 'roll' measurement.

6.6 Components Used

Component	Supplier and Part Number	Quantity	Cost
Microcontroller	Texas Instruments: MSP430F2274	1	Sample
Gyroscope	STMicroelectronics: L3G4200D	3	$6.94 (each)
Battery		1	
LCD	Newhaven Display: NHD-0224BZ1-FSW-FBW	1	$15.00
Control Button		2	
Power Switch		1	
PCB	PCBexpress	1	$109.00-$139.00
FTDI Cable	FTDI	1	$20.00-$30.00

7 DELIVERABLES

The final projected product will be an alignment tool specifically designed for use with machine rollers, based on a battery-powered microcontroller. The device will perform all measurements with the guidance of multiple on-board gyroscopes which will be calibrated to a single roller for comparison. The alignment tool will be able to output its reading to a client program on a separate computer system via a USB connection, which will in turn be able to capture the device output and graph this saved information.

8 MATERIALS REFERENCED

- MSP430 Manuals and Documentation
- L3G4200D Documentation
- Texas Instruments Embedded Processors wiki [processors.wiki.ti.com]
- Self-Balancing MSP430 Robot Project [http://processors.wiki.ti.com/index.php/Self_Balancing_MSP430_Bot]

9 PROJECT MANAGEMENT

9.1 Team Structure

Ellen Laird - Communication Officer: Initiate and maintain communication with advisor, client and third parties. As the sole electrical engineer in the group, will focus on the hardware design, components and construction.

Ted Beem – Website Manager: Create and maintain group website, including upload of new documentation and relevant information updates. Also responsible for design of device's physical shell structure.

Aaron Peterson – Team Leader: Organize group structure and track overall team synergy. Responsible for hardware-software interface and PC communication.

9.2 Statement of Work

1) Finalize circuit components and obtain samples.
2) Design a basic, usable computer interface to communicate with tool via the microcontroller.
3) Determine how components work/connect. (input/output pins, supply voltages)
4) Design a setup for components. (connect components together, layout within size restraints)

5) Buttons and LCD screen implemented and working.
6) Take readings from each gyroscope individually and interpret them appropriately.
7) Display live measurements on computer interface when USB connected.
8) Display live measurements on LCD screen.
9) Able to capture readings from tool, with computer or buttons on tool.
10) Memory storage on tool for 'capture' feature. (able to access readings once USB connected to computer)
11) Design a method to test layout. (test should involve turning layout a known number of degrees off calibration point)
12) Obtain accurate readings about displacement, from test layout, on LCD and computer.

First Semester Goal: Have circuit components put together in a test setup and able to program and receive data from the microcontroller. Able to receive pitch and yaw readings from the microcontroller and display them on a computer or LCD in a live feed. Tool's physical shape designed and ready for manufacturing.

All machining provided by PowerFilm, Inc.

9.3 Project Schedule

Week(s)	Tasks Accomplished During Week
1-2	Choose project and meet group members and advisor
3	Met client and toured facility
4-5	First draft of Project Plan and begin research components that will be needed to make the desired tool
6-8	First draft of Design Document: components for circuit layout, input and output, order in which the components will talk to each other slaves vs. masters. Website operational with accessible documentation. Full software block diagram complete.
9	Spring Break
10-11	Finalize Circuit design with connections and components. Coding environment installed and initialized. Contact resources regarding connection and structure design.
12	Meet with client to discuss circuit design and order components. Design PCBs based on finalized circuit design. SPI groundwork laid down for future device communication. Determine modeling design approach.
13	Begin assembling hardware as components are received. Debugging issues as they arise. Communication with microcontroller established.
14	Prepare presentation for faculty review. Able to produce human-readable output from gyroscope(s). First draft of model complete.
15	Faculty Presentation. Full prototype with physical connection to roller available.