3D Laser Range Finder

Topological sensor gathering spatial data from the surrounding environment

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Project Description

Project Name:
3D Laser Range Finder

Project Members:
Christian Conrose
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Project Sponsors:
The Robotics Club at UCF and Dr. Daniel Barber at the Institute for Simulation and Training will be sponsoring the 2D LIDAR sensor for use in this project. Due to the price of the sensor we are unable to acquire the sensor ourselves. Dr. Barber has agreed to loan us the Hokuyo UTM-30LX LIDAR for use in this project with the hopes of being able to utilize the end product.

Project Narrative:
With the increasing complexity of modern manufacturing and the birth of 3D printing the demand for acquiring spatial data from an environment has never been higher. Whether it is a desktop 3D printer or an autonomous car there have been many breakthroughs in the past few years which have expanded the ability of current light based detection and ranging sensors. These advancements come at a price and that price is often in the tens of thousands of dollars. Lower cost alternatives have been on the market for some time and have come in some surprising forms but usually have tradeoffs. The Xbox Kinect for example is a gaming camera device that can achieve many of these functions but fails to work outside or at long distances due to its IR camera.

The goal of this project is to create a three-dimensional sensor capable of

Figure 1 Depth Image Example

remaining low cost while still retaining all of the accuracy, precision, and speed of higher cost solutions. While the final assembly will have many useful functions the primary role will be for utilization by the Robotics Club at UCF for their many autonomous robotic platforms.

Functionally speaking the project will be a fully embedded 3D solution leveraging a very capable 2D laser scanner (Figure 2).In order to generate 3D data the sensor is to be placed upon a yet to be fabricated mount which will pitch the sensor up and down. The mechanical device should not restrict the wide field of view of the sensor itself and in addition shouldminimize translational errors due to physical sensor movement during scans. The included synchronization line from the Hokuyo 2D scanner will be integrated to allow for a continuous control design. The pitch velocity of the sensor will be calculated for offsetting each scan from the device via a closed loop design. Motor shaft positing will be critical inpoint generation enablingquicker scans. Ideally users of the device will be capable of reconfiguring parameters on the fly to allow for increased resolution, improved scan times, or more isolated F.O.V.

Many additional software features are planned including accurate depth mapping and live perspective transforming to real time camera feeds as demonstrated in Figure 1. This data will be sent out via a network connection in the system and will implement the SAE JAUS communications standard. This standard will allow for greater interoperability with existing and future robotics systems in which this project intends to be integrated. Implementation of a DOD grounded communication standard will allow for more reliability in the system performance and will offer significant advantages over similar systems without compliance.This standard will allow for streaming of image data generated from each full scan real-time to multiple platforms if desired across a network.

Figure 2 Hokuyo UTM-30LX LIDAR

Specifications and Requirements

Physical
- Occupy less than 3 cubic feet.
- Mounting options on 2 axes.
- Weigh less than 5 pounds.

Scans
- Scanning time will be 1.5 sec / scan or better for 45° scans.
- The assembly will be capable of atleast 160° horizontal F.O.V.
- The assembly will be capable of at least90° vertical F.O.V.
- Angular resolution on all axes will be at least 0.5° or better.
- Ranges from 0.1 to 30 meters.
- Real timeconfiguration of these parameters.

Power
- Will run on a single power rail (12/24 V).
- Maximum power consumption will not exceed 36 W.
- Onboard regulation for all components.

Interfaces
- Power switch.
- Reset switch.
- E-Stop switch.
- PC connection (Ethernet / USB)
- Power connection

Software
- SAE JAUS compliance.
- Drivers, visualization, and monitoring software will be cross-platform.
- All software will be open-sourced and well documented.

Operating Conditions
- Performance will be identical both in indoor / outdoor environments.
- Operating temperatures will be from at least 0 to +50° C.
- Weather proof, IP 45 or better.
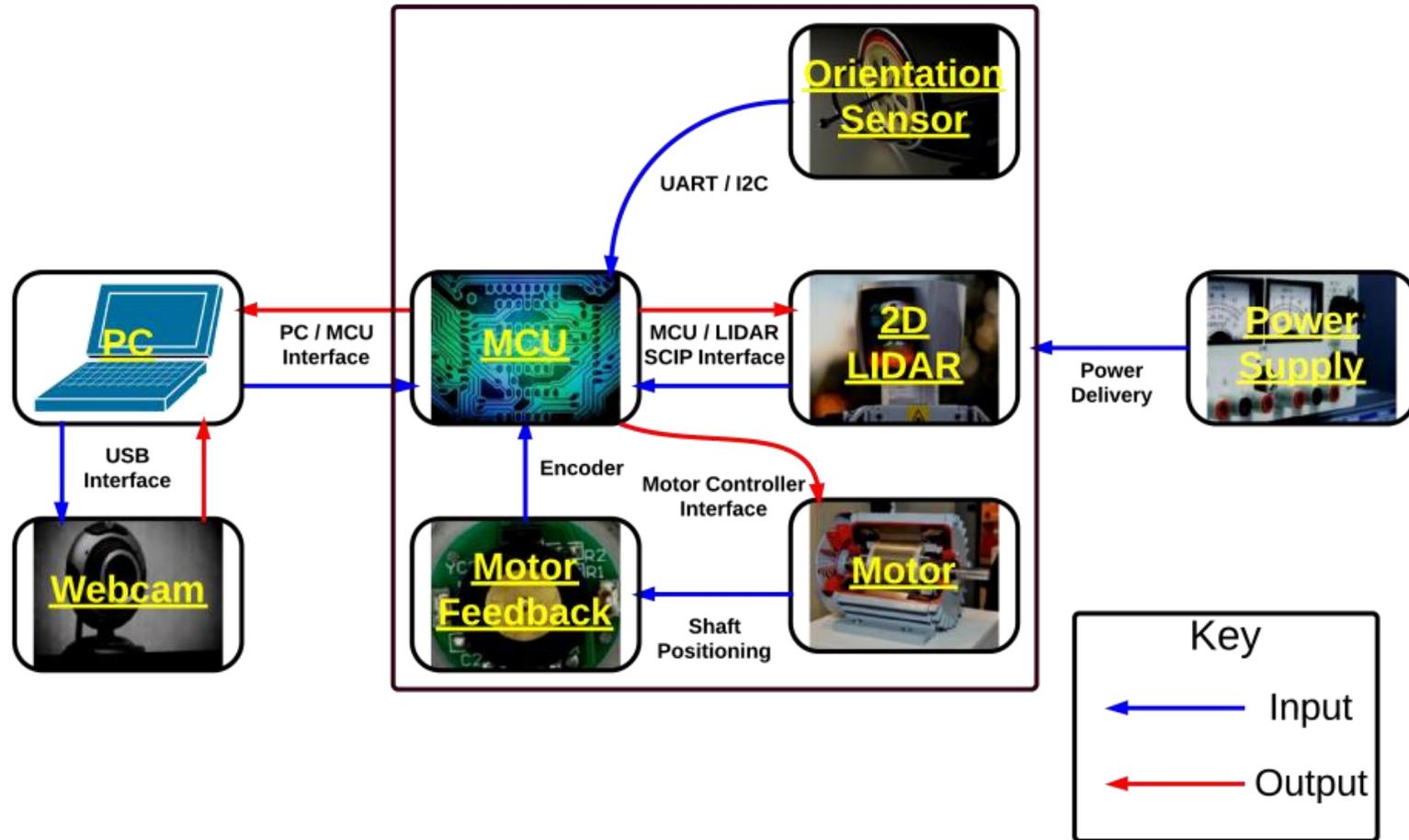
Hardware Block Diagram

Figure 3 Hardware Diagram

Hardware Block Diagram Status

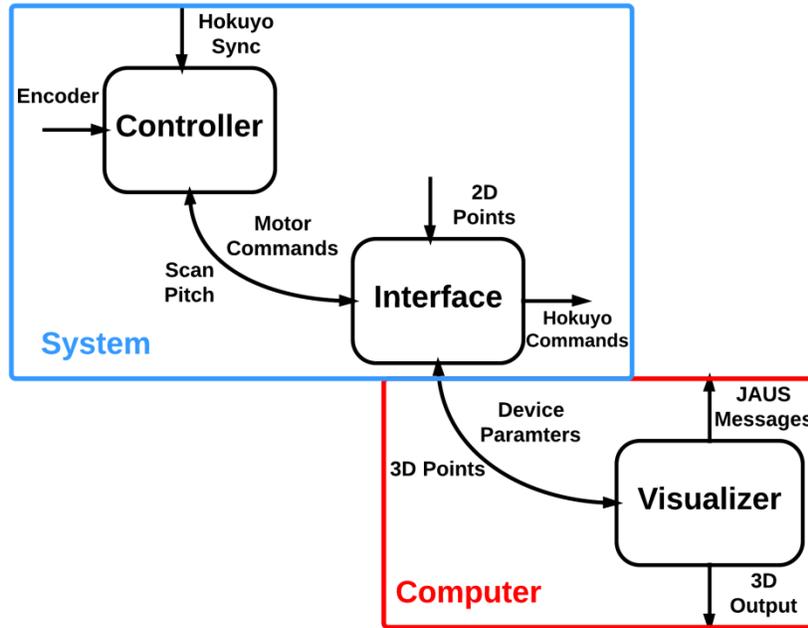| Component	Member	Status	Details
2D LIDAR	Andrew	Acquired	Hokuyo UTM-30LX LIDAR
Power Supply	Christian	Research	Power Delivery to PCB , Motor, and LIDAR
Microcontroller (MCU)	Christian / Andrew	Research	MCU for low level motor commands and sensor input
Orientation Sensor	Jonathan	Research	Detect scanner orientation and auto-adjust output
Motor	Jonathan	Research	Controlling pitch angle of scanning assembly
Webcam	Jonathan / Christian	Acquired	Real time video depth imaging and perspective transforming
PC	Andrew / Jonathan	Acquired	Processing high level point clouds and other visually intense processing

Table 1 Hardware Status

Software Block Diagram

Software Block Diagram Status

Component	Member	Status	Details
Motor Control	Christian	Planning	Low level motor driving.
PC Interface	Christian / Andrew	Planning	Shared memory / network message data packaging.
JAUS Service	Andrew	Planning	Compliance with JAUS standards.
Motor Command Interface	Jonathan	Planning	Motor parameters / closed loop controller.
Depth Image Processing	Jonathan / Christian	Planning	Image construction and transposition to camera images.
3D Scan Implementation	Jonathan / Andrew	Planning	Point cloud generation and time stamping.

Table 2 Software Status

Budget

Component	Price
Hokuyo UTM-30LX 2D LIDAR	$6000, donated by UCF Robotics Club
3D Printer Material / PLA Spool	$50
Gears, Motors, Mechanical Misc.	$200
PCB, Parts, Connectors, Electric Misc.	$200
USB Webcam / PC	$300

Table 3 Budget

Total Estimated Cost: $6750

Project Milestones

Title	Begin Date	End Date	Sep '13	Oct '13	Nov '13	Dec '13	Jan '14	Feb '14	Mar '14	Apr '14
Project Document	9/12/2013	9/17/2013	███							
Research			███	███						
Laser Sampling Controls	9/17/2013	9/24/2013	███							
Laser Interfacing (MCU)	9/17/2013	9/24/2013	███							
Mechanical Control System	9/17/2013	9/24/2013	███							
PC Interfacing	9/17/2013	9/24/2013	███							
Debugging Interface	9/25/2013	10/15/2013		███						
Software Library Research	9/25/2013	10/15/2013		███						
Repository Setup	9/25/2013	10/15/2013		███						
Camera Perspective Transformation	9/25/2013	10/15/2013		███						
Design	10/16/2013	12/31/2013		███	███	███				
Tilting Mount	10/16/2013	10/31/2013		███						
PCB Design	12/1/2013	12/31/2013				███				

Title	Begin Date	End Date	Sep '13	Oct '13	Nov '13	Dec '13	Jan '14	Feb '14	Mar '14	Apr '14
Driver Software	10/16/2013	12/31/2013		■	■	■				
PC Software	10/16/2013	11/30/2013		■	■					
Electrical Components	10/16/2013	12/31/2013		■	■	■				
Build	12/15/2013	4/30/2014				■	■	■	■	■
PCB Board	2/1/2014	3/31/2014						■	■	
PC Driver Board	12/15/2013	1/15/2014				■	■			
PC Software	1/1/2014	2/28/2014					■	■		
Laser Scanner	12/15/2013	1/31/2014				■	■			
Testing	12/15/2014	4/30/2014								
Continuously	12/15/2014	4/30/2014				■	■	■	■	■

Table 4 Milestones