University of Colorado Boulder

PROJECT PROPOSAL

ADVANCED EMBEDDED SOFTWARE DEVELOPMENT

SPRING 2019

SMART CART

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DESCRIPTION AND REQUIREMENTS DOCUMENT

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INTRODUCTION

Quick and cashless transactions have become the need of the hour, particularly at places like supermarkets where one has to put in ample amount of time looking for the regular products. According to a survey by Time Use Institute, at an average a person spends 41 minutes per trip at the supermarket. This sums up to an average of 53 hours per year when multiplied by the average number of trips per week. All this time can be saved by employing a much smarter approach to our daily shopping trips. Smart cart is one of the many solutions to reduce your shopping time. What we intend to do in this project is explained in great detail in the following sections.

PROJECT DESCRIPTION

OVERALL CAPABILITIES OF THE SYSTEM

- The project aims at developing a multi-controller product using the BeagleBone Green, Tiva C-Series LaunchPad development board, off-board sensors and output devices. The overall objective is to design and implement a monitoring/control system comprised of a controller/server node (Control node) remotely connected to and controlling a remote sensor/output node (Remote node).
- The Remote node will provide the sensing capabilities whose data will be reported to the Control node which will make real-time decisions based on the data and events. The Control node will then provide appropriate feedback to the Remote Node. The Remote node will drive the output(s) based on the control signal it receives from the Control node.
- The Remote node is comprised of the TI Tiva C-Series LaunchPad development board running a customized FreeRTOS image with multiple off-board sensors and output devices. It is connected to the Control node, a Linux-based BeagleBone Green, via a communication link.
- The application of the project is a SMART CART which will consist of three different sensors (RFID sensor, Ultrasonic sensor, Gesture sensor). Based on the sensor data and the control signal from the Control node, 3 output devices (2 motors, Display/Buzzer) will be driven.

SENSORS AND OUTPUT DEVICES

- **RFID SENSOR & RFID TAGS:**
  i. RFID (Radio Frequency Identification) is a technology designed to identify things as they pass within range of a radio-based reader, in much the same way as a barcode serves to identify a thing that passes beneath a laser scanner.
  ii. RFID, however has a number of advantages when compared to the traditional barcode.
  iii. Firstly, the RFID tag just needs to be in the radio range of the RFID transponder to get scanned. This implies that the package orientation is unimportant.
  iv. Secondly, RFID tags are resistant to dirt, heat, paint etc. giving them a significant advantage over barcodes that can be torn or removed, thereby making it difficult to identify/scan that item.

Each of the items need to have an RFID tag attached to it. This works similar to Barcode where each item has a unique Barcode associated with it making it easy for the system to identify a particular item.

A RFID scanner can be placed in the cart in order to scan the item/product to be bought. This will eventually calculate the Bill dynamically as an when the item is added or removed from the cart. For the scope of this project, we will not be aiming to handle the case where in the item once scanned is removed from the cart. To indicate the detection of an RFID tag we plan to display a message on the LCD or by switching on an LED.

The sensor being used to simulate this is **PN532** (https://www.nxp.com/docs/en/nxp/data-sheets/PN532_C1.pdf).

- **APDS – 9960 GESTURE SENSOR:**
  i. This sensor will be used to detect hand gestures and drive the cart based on the gesture input. The APDS - 9600 Gesture sensor utilizes four directional photodiodes to sense the reflected IR energy to convert the physical motion information to a digital information. The gesture engine accommodates a wide range of mobile device gesturing requirements: UP-DOWN-RIGHT-LEFT. Based on the detected gesture, the motorized cart will be driven in that particular direction.

  The sensor being planed to use is an **APDS – 9960 Gesture sensor** (https://cdn.sparkfun.com/assets/learn_tutorials/3/2/1/Avago-APDS-9960-datasheet.pdf)

- **ULTRASONIC SENSOR:**
  i. As discussed in the above two sensor description, a gesture sensor will be used to drive the Smart Cart in the desired direction based on the gesture input. To have a safe environment, we plan to use an Ultrasonic sensor to avoid the Cart from crashing into obstacles/people. As soon as the cart nears an obstacle, it will stop the motors of the cart. This will ensure that the cart does not go beyond the control of the user.

  The **HC-SRO4** sensor will be used to fulfil this purpose.

The system will consist of three output devices/ actuators. The first two being the **motors** which will be driven based on the gesture input. The third output device which we plan to use is an **LCD or a buzzer** to indicate completion of various tasks.

REQUIREMENTS

REMOTE NODE REQUIREMENTS

Req ID	USE CASE
RN 1	The remote node should start the data acquisition software on power-up without any manual intervention or configuration
RN 2	The TIVA board in remote node should have minimum two sensors and two Actuators
RN 3	The remote node should detect and notify the control node, about the faults/failure of any sensor during the start-up operation
RN 4	The remote node should run in degraded mode if only RFID sensor is inactive and other sensors and communication link is active
RN 5	The remote node should run in fail-safe mode if the Ultra-sonic sensor or control node is inactive
RN 6	The remote node should shut-down if the gesture sensor is inactive
RN 7	Date of each sensor from TIVA board should be periodically reported to the control node
RN 8	The remote node should trigger the actuators depending on the feedback signals received from the control node
RN 9	The Remote node should carry-on the data acquisition even in the absence of the control node (But not trigger any actuator when control node is inactive)
RN10	The remote node should log all the operational modes, errors, alert, warning, sensor data, sent/received communication data and actuator events via the logger task
RN 11	Upon restoration of communication between Control node and Remote node, the Remote node data/events shall be forwarded to the Control node.

CONTROL NODE REQUIREMENTS

Req ID	USE CASE
CN 1	The control node should have a customized Linux image
CN 2	The control node should start the software on power-up without any manual intervention or configuration
CN 3	The system should log all the data, errors, warnings, alert signals in all the mode of operation
CN 4	The control node should take the decisions based on the input (from remote node) and provide feedback to the remote node
CN 5	Control node should detect the Arrival and Disappearance of Remote Node.
CN 6	Control Node should log all the events from remote node and all the feedback in control node
CN 7	Control Node should trigger bugger and red led for degraded and fail/safe operation mode

ACTUATOR REQUIREMENTS

Req ID	USE CASE
A1	The motor M1 and M2 should run in clockwise direction if the APDS 9960 sensor detects a forward hand gesture
A2	The motor M1 and M2 should run in anti-clockwise direction if the APDS 9960 sensor detects a backward hand gesture
A3	The motor M1 and M2 should run in clockwise and anti-clockwise direction respectively if the APDS 9960 sensor detects a right gesture
A4	The motor M1 and M2 should run in anti-clockwise and clockwise direction respectively if the APDS 9960 sensor detects a left gesture
A5	The M1 and M2 should not run if there is no proper hand gesture or ultrasonic sensor value is above the collision prevention threshold
A6	The bugger/led should be triggered on a valid RFID sensor event
A7	The display should show the product name on screen if the RFID sensor scans a valid card and if the UUID of the card matches if the pre-stored UUID
A8	If there is no RFID sensor event, then the display should show “Scan the product here”

COMMUNICATION REQUIREMENT

Req ID	USE CASE
C1	The remote node and the control node should communicate between them using a full-duplex wired / wireless communication method
C2	The network configuration of the system should be statically pre-configured