Design Overview Document

ROBOCON-OCU

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1. Product Description

Mobile robots have come a long way both in autonomous functionality and terms of movement capabilities. However, in various scenarios, mobile robots still need humans when it comes to making decisions. These scenarios require operators to control the robots with remote controls. While there are a lot of well established mobile robot platforms, operator control units lag behind a lot. The absence of a robust, secure and practical operator control unit that can stream HD video and transfer control inputs real time over long distances to any robot is still a big, unsolved problem. We aim to solve this problem.

The end product for this project is a standalone Operator Control Unit (OCU) that can be used by field operators that control mobile robots in the field. This unit will consist of two parts: the operator system and the on-board system. Operator system basically will be a remote control that has joysticks, buttons and an LCD screen that designed to be very practical for several field scenarios. The on-board system is the bridge between the operator system and the robot itself with a wired connection between each other. On-board system takes various kinds of state information from the robot such as battery life, operation mode with the video stream from the cameras on the robot and it transfers this information to the operator system. Similarly, the on-board system will transfer control commands received from the operator system to the robot in real time fashion. There will be a robust, secure and reliable wireless connection between these two systems.

2. High-Level System View

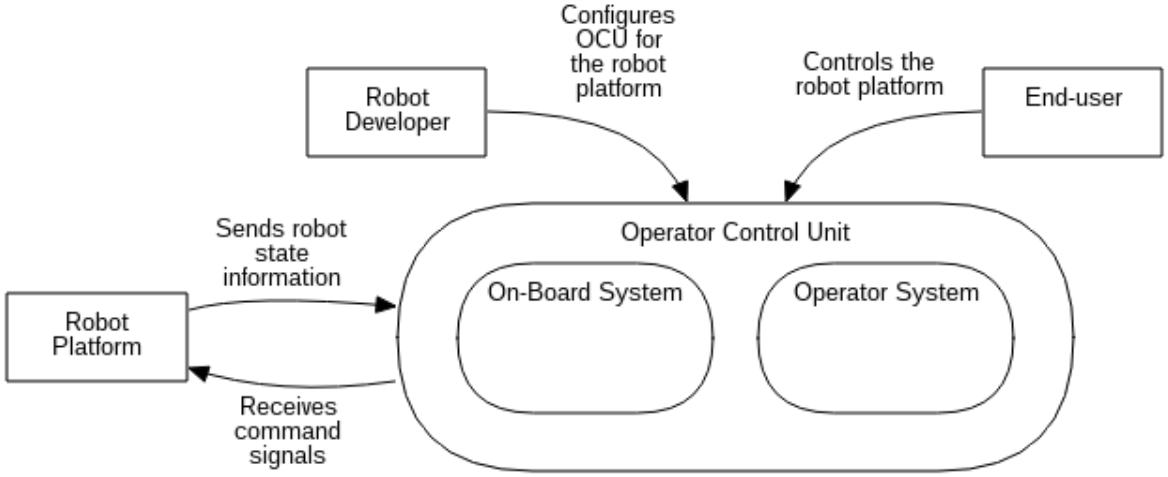

Figure 1: High Level System View

Control unit itself, consists of two subsystems: on-board system and operator system. The main target audience for our product is military personnel, researchers and professional hobbyists. The controller unit will be utilized in the various field scenarios by the end users. Since, the product will be a configurable control unit, a robot developer must step in and make use of the control unit using our API to suit their needs accordingly. Lastly, robot platform is the entity that our OCU controls. It broadcasts the state and/or any sensory information available and listens for commands from control unit while streaming HD video from the robot to the Operator System.

3. Overall System Design

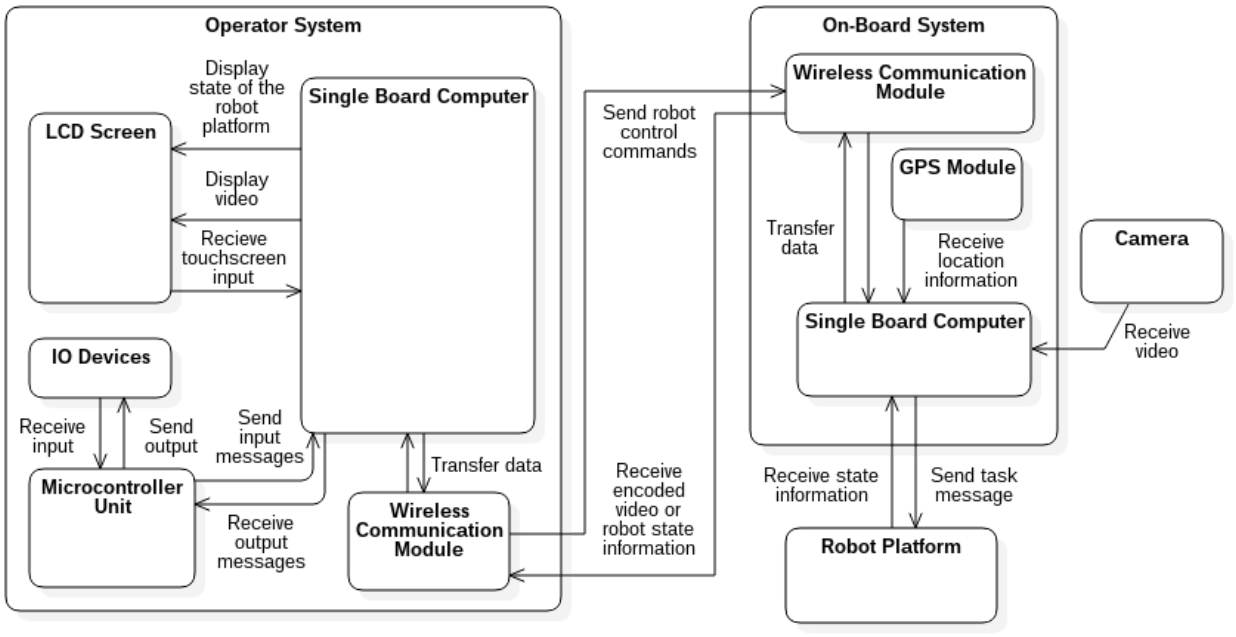

Figure 2: Hardware System Design

Hardware system design of OCU is planned as above. There exist two main units, operator system and on-board system in OCU.

Operator system contains two primary components in itself, which are the single board computer (SBC) and the microcontroller unit (MCU). Main objects of the SBC module are sending, receiving and processing data. SBC connects with the LCD screen, MCU, and wireless communication module (WCM). LCD screen is the hardware component where GUI will meet with the end-user. The input received from the end-user will be transferred to SBC to be processed. Additionally, robot state information and streamed video will also be passed from SBC to LCD screen. Second part of the operator system is the MCU. MCU will be the bridge between I/O devices and the SBC. Microcontroller's mission is to receive input from the peripherals like buttons and joysticks. After receiving these inputs, sending them to SBC to make them be processed is the main idea. MCU also receives signals for the output peripherals like LEDs from the SBC.

On-board system will be the unit to be connected with the robot and a camera. Main jobs of the on-board system are receiving the state of the robot from the robot platform which will be connected to on-board system's SBC, send that information to the

operator system over a wireless communication module(WCM), encoding the received video from the camera in real-time also in SBC and streaming it over wireless communication module to the operator system. In addition, the WCM in on-board system will receive robot control commands from the operator system. The on-board system will be connected to the robot platform and will receive robot state information including location information (by its GPS module).

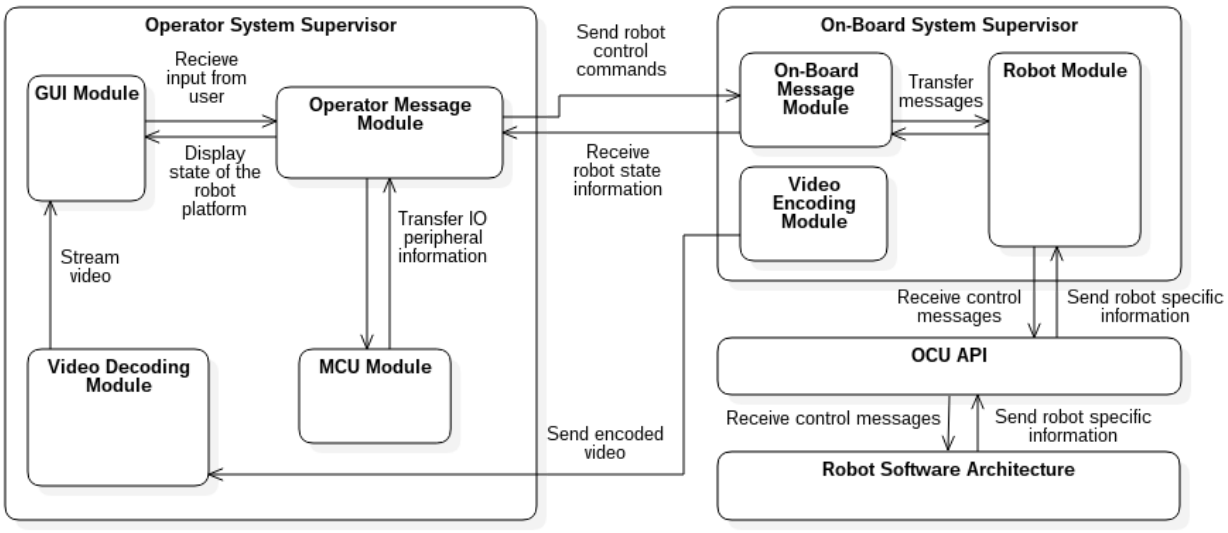

Figure 3: Software System Design

Software system design of OCU is planned as above. There are two main programs in the OCU, the first one is called Operator System Supervisor and it is responsible for the operations done on the Operator System. It consists of four modules. GUI Module shows user various information about the robot and its surroundings. It can also take inputs from the user and gives it to the Operator Message Module to be sent to the robot platform. Video Decoding Module gets the encoded video from the On-Board System, decodes it and sends it to the GUI Module to be displayed on the LCD screen. MCU Module transfers the information gathered from the peripherals to the Operator Message Module to be sent to the robot. MCU Module runs both on the microcontroller and single board computer of the Operator System. Operator Message Module is responsible for receiving and sending command and information messages between On-board System and Operator system.

The second main program is On-Board System Supervisor and it is responsible for the operations done on the On-Board system. It consists of three modules. Video Encoding Module gets the raw video from the camera(s), encodes it and sends it to the Video Decoding Module of Operator System. On-Board Message Module is responsible for

receiving and sending command and state information between On-board System and Operator system. Lastly, Robot Module is responsible for the communication between the robot platform and On-Board System.

Developers of the robot platforms would utilize the OCU API in their robot platform to make use of the OCU. This API and the Robot Module of On-Board system would work together to send and receive command messages and useful state information between the Operator System and the robot.

4. Alternative Design Options

Need for on-board system

One of the alternative designs can be excluding the on-board system. In these kinds of designs, the operator control unit and the robot platform are manufactured from the same company. Therefore, the remote control mechanism is already known which platforms that can be used for. There is a simple synchronization done to distinguish which robot platform is used before the operator system starts. Our aim is design and built an operator control system which is adaptable for all kinds of mobile and legged robots. In order to accomplish this, we offer an API that developers can modify according to their own robots built by themselves or bought. We offer a hardware called on-board system which handles the overall communication between the operator system and the robot. In the on-board system, we provide inputs for camera(s) and GPS to enhance the capabilities of OCU. With this provided hardware, developers can also control the robots that do not have a camera and a GPS. In addition, they can make use of video and mapping feature of the operator controller system. Another feature is that encoding the video in the on-board system; thus, the robot's computational power would not be wasted.

Wi-Fi over radio

Since we need a relatively high bandwidth for our HD video streaming feature, we have decided to use Wifi instead of radio based communication.

Using a discrete microcontroller

Since we plan to use many buttons, joysticks and other peripherals, we decided to use an extra microcontroller to compensate our lack of GPIO(general purpose input-output) ports on our single board computers. With our approximations, we may need 30-40 ports roughly. Therefore, we bought another microcontroller.