Programming of Embedded Systems
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Summary of Pan and Tilt project

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1 Introduction

The goal of the project was to implement a pan and tilt device, which is used to aim a camera. To implement the pan and tilt device, the embedded system will control the motors that move the camera in each direction. The input will be provided by input via network. The camera stream is directed to the client over an SSH stream.

A pan and tilt device with a camera can be used to survey a room or environment without being on site. The movement of the camera allows the system to monitor an area much larger than what is possible with a static camera. The movements can be controlled interactively from the client software.

The typical use case for the system is a room indoors. No considerations are made to weatherproof the equipment, and lighting and power is assumed to be reliable. No special assumptions are made about placement of the finished device, but movement should be unrestricted, and since the design doesn't provide 360° coverage a corner or wall position is recommended.

2 Hardware

Mechanical rig

The mechanical rig consists of a set of plastic arches constructed with a 3D-printer which will hold the servo motors and camera in place. The arches have been custom designed to match the mounting holes of the motors and camera and to make sure that the tilt and pan movements of the camera will have sufficient range of motion. Plastic was chosen for the rig because it is easy to make a prototype with and given the overall low weight of the system the arches will have no trouble supporting the structure. The various parts of the mechanical rig will be joined together with screw and nut. The design for the mechanical rig is presented in Figure 1.

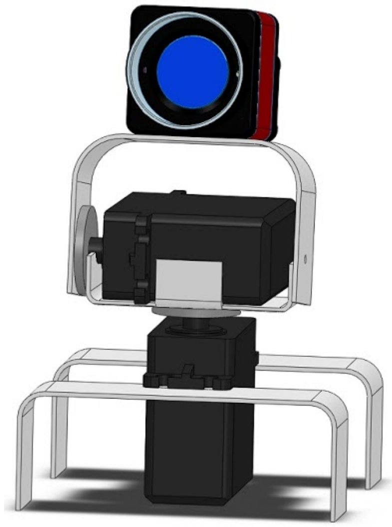

Figure 1: The design for the mechanical rig for the Pan and Tilt device.

Major hardware platform

The ARM11 based PI [Raspberry PI Foundation, 2014] has sufficient processing power to handle video streams directly, making it's ethernet port the primary interface for both user input and output. It has UART and SPI hardware for communication with other components such as the servo controller, and runs the Xenomai realtime extension for Linux.

Servos

Since movement has to be done in two planes the project requires two servo motors. The type selected is the Hitec HS-322HD [HiTEC, 2002]. This servo has a suitable form-factor, and is controlled with a PWM signal. But in the end it was selected on the basis of availability, since the group had access to a few units.

Servo PWM controller

A layer of abstraction will be added between the hardware accepting user input, and the servos. This is because the Raspberry PI only has a single PWM output, and we want to keep the option of using a PI as the hardware platform for the project. The servo PWM controller will be implemented on an MSP430 microcontroller [Texas Instruments, 2013] running no operating system. It will communicate with the other hardware over UART, with the option of using UART for more interactive control.

Camera

The Raspberry Pi Camera Module is used, which is a small HD camera with a fixed focus lens, it has an interface that can be connected directly to a Rapsberry PI. It doesn't run over USB, and gives access to both still images and videostreams. The fact the design is meant to be open means it should be possible to make use of it even if another operating system than Linux is used.

3 Software

The software is split into three parts; The server-client interface used to send commands over the network, the real time module which controls the motor movement, and the MSP430, which controls the motors using PWM. An overview of the system can be seen in figure 2. The real time module runs four tasks, one which listens for inputs from the server, which are sent over a real time pipe. The actual movement is controlled by two tasks, one for pan and one for tilt, which provide the smooth movement of the camera to the specified angles. The last task is the queue task, which updates the pan and tilt tasks with the next value from the server.

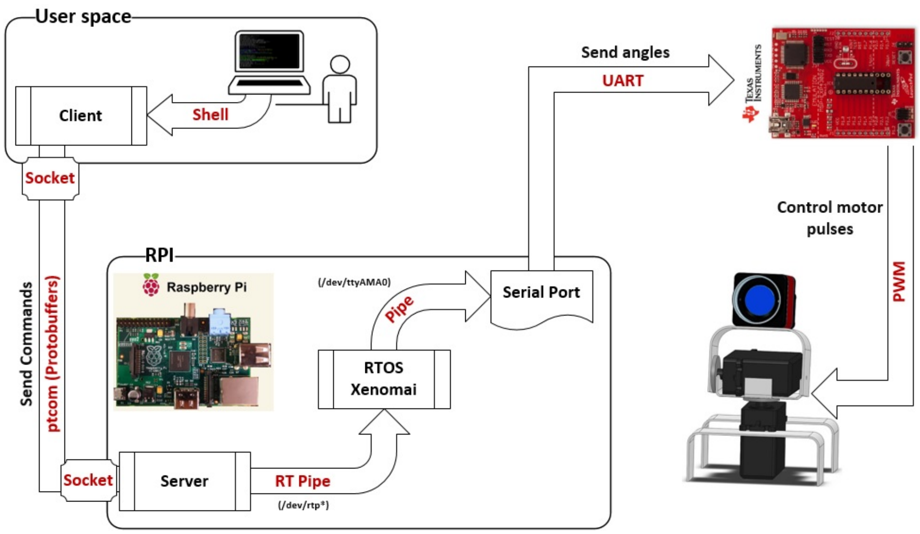

Figure 2: An overview of the Software Architecture for the Pan and Tilt device.

4 The finished product

A photo of the finished product is presented in Figure 3.

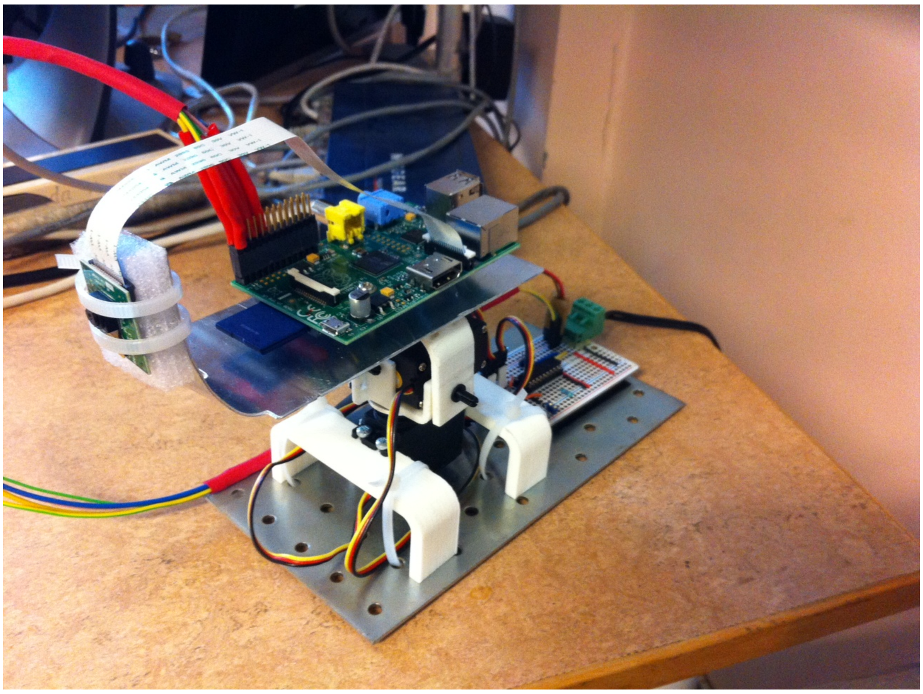

Figure 3: The final version of the product.

5 Future work

The possible improvements to the current design includes the ability to automatically aim the camera based on sound input. To do this, several microphones would be connected to the system, and used to calculate the direction from which sound originates, and point the camera in that direction.

References

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