Simultaneous Personnel Localization and Mapping

A Major Qualifying Project Report Submitted to the Faculty of
Worcester Polytechnic Institute

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Abstract

The overall goal of this project is to create a device capable of generating detailed maps and imagery of an area in real-time. This device will rely on an FPGA, and will use image processing algorithms capable of detecting, localizing, and tracking human beings. The device will gather imagery from the visual light and infrared-spectrums, as well as localization data and distance measurements from an IMU and a rangefinder. Along with gathering and processing data, the device will also serve as a long-range wireless access point, and will be able to transmit all generated maps and imagery in real-time. A major deliverable of this project is that the transmitted data will be fully processed, allowing it to be viewed remotely on less-powerful, mobile devices.

This device will be especially useful for first responders. It is intended to be mounted on a small remote control vehicle, allowing any connected user to wirelessly traverse dangerous and remote locations in search of people in need. Since this device transmits data in real-time, it will be able to provide first responders with an accurate representation of not only a 2-D floor plan of an area such as a building, but also where any people are located. An anticipated use of this device would be in the event of a building in danger of collapsing. Since it would be dangerous to physically enter the building, first responders could locate any people trapped inside and find the fastest route to them using the wirelessly transmitted floorplan. The first responders would also be aware of any dangers in their way by making use of the real-time augmented video stream. This video stream will consist of image data with overlaid with object indicators and location information on any human beings detected by the image processing algorithms.

1 Introduction

Currently there are many applications that rely on a simple video camera setup in order to gather information on remote and inaccessible locations. Although this is an effective strategy for simple surveillance, it is limited in many ways. Using current imaging and sensor technology, it is possible to gather camera images and 3D depth information on a given area as both a cost-effective and information-rich alternative to using a camera module on a device. If a product were to be created that gathers this information as a replacement to using a standalone camera module, it would be possible to use high speed data processing techniques in both hardware and firmware that would allow for the creation of an augmented real-time video feed.

This type of technology is known as Simultaneous Localization And Mapping, or SLAM. The purpose of SLAM is to compute the location of an agent within its environment, and allows for the creation of self-aware robot systems that are able to respond to their surroundings. SLAM is a common area of research in the image processing and high-speed computing field, and has been applied mainly to autonomous vehicles. We would like to propose the creation of a SLAM-like system that is capable of monitoring and mapping its environment in real-time, as well as detecting and localizing objects, such as human beings. For the purposes of our project, we would like to define our desired objective as Simultaneous Personnel Localization And Mapping, or SPLAM.

A device that is capable of both mapping its surroundings using SLAM and performing human detection in real-time would be applicable to many different fields. We are especially interested in creating a proof of concept sensor suite capable of performing these tasks that can be added to existing robotic systems as a stand-in replacement for a video camera. This type of technology would allow for people such as firefighters or first responders to wirelessly traverse dangerous and remote locations in search of people in need. We envision our sensor suite being able to process data so that its users would be provided with a 2D ?floorplan? of the area being traversed by the sensor suite, as well as an augmented video feed with imagery containing indicators for any detected human beings in the area.

One type of technology that would be useful for performing the high speed data processing necessary for SPLAM is a Field Programmable Gate Array , or FPGA. FPGAs pose several advantages over using standard computing or microcontroller technology for real-time data processing, as they have the ability to manipulate digital information in parallel using hardware only. This allows for extremely high-speed performance, as calculations can be run in parallel and are only dependent on their data inputs as opposed to waiting for specific tasks or scripts to run on a microcontroller or computer software interface.

Although FPGA technology is highly applicable to performing SLAM-like tasks due to its high speed, there are currently few existing commercial products that use FPGAs for the purpose of performing SLAM. Most current SLAM implementations rely on the use of a sensor suite connected to a computer or system on chip (SoC) computing device that performs data analysis using software or a real-time operating system (RTOS). This means that data must first be collected by a sensor suite, and then transferred to an external computing device that is only capable of processing it serially based on its arrival time. Although this type of setup is acceptable for performing real-time situational awareness analysis, we propose that an embedded, FPGA-based SPLAM device would be a much more elegant and higher-speed solution.

References

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[5] Sebastian Thrun, D.H., David Ferguson, Michael Montemerlo, Rudolph Triebel, and C.B. Wolfram Burgard, Zachary Omohundro, Scott Thayer, William Whittaker. *A System for Volumetric Robotic Mapping of Abandoned Mines.* in *IEEE International Conference on Robotics and Automation.* 2003.

LaTeX Coding Examples

This section isn't intended to remain here, but can serve as an example for how to set things up later on

1.1 Figures

Figure 1: A Test Figure

Using the `\ref` command, I'm able to reference Figure 1 by calling `\ref{wpiLogo}`.

1.2 Code Snippet

Code snippets can be created by calling `\begin{lstlisting}`, inserting all code, and then calling `\end{lstlisting}`. Also call `\singlespacing` before the code snippet and `\doublespacing` after to keep things from getting too big.

```
//verilog code example
always @ (x, y, z)
  x <= y + z;
```

1.3 Using the bibliography

All bibliographic references are contained in `bib.tex`. To cite a reference in the paper, use the `\cite` command.

As an example, I can cite *Serveball* at the end of this sentence by calling `\cite{serveball}`.[2]

To cite multiple references, call `\cite{ref1,ref2}`.[2, 4]