Communication between camera and system

Sarah Aggoun
0890338
Ronald van Gils
Wouter Bergmann-Tiest
Sandra Hekkelman
First occasion

13-04-2019

Glossary

Clock Signal which oscillates between high and low and is used as a metronome to synchronize actions

CPU Central processing unit

CSI Camera serial interface

Multiplexer Device that allows you to switch between multiple inputs on a single output line

Raspberry Pi Small single board computer

Stereoscopy Using two pictures taken of the same object but at different angles to create a 3D image.

Executive summary

To monitor a newborn's health, its length gets measured after birth. However, handling newborns too much, can have negative consequences too their health. This is especially true for infants in incubators who need the added protection.

A possible way to measure an infants length without handling it, is by stereoscopy. With stereoscopy, two cameras are facing an object from different angles. Both these cameras will take a picture at the same time after which these pictures can be combined to create a single 3D image. By taking these two pictures of an infant, specific points of interest can be marked on both images. These points of interest can then be converted into a 3D image after which the distances between the points can be calculated. All that remains then is adding up all the measured distances to get the length of the infant.

The above-mentioned method needs to be built and tested for accuracy. To do this, a testing-setup needs to be built. This testing-setup will have to consist of at least two cameras to take the pictures and a computer to do the calculations. For the computer to be able to use the pictures, it needs to be able to communicate with the cameras. There are multiple ways to accomplish this, which will be covered in this report. The main question can be stated as:

> Which protocol for communication is best suited for the aforementioned stereoscopy project?

This main question can be split into the following sub-questions:

1. Which options for communication-protocols are available?
2. How do these options work?
3. How do these options compare to each other?

The aim of this research study was to answer the questions stated above. Through literature study, multiple options for communication have been researched after which, they were compared to one another.

The options that were considered for the communication, were USB and CSI. Out of these two, CSI seemed to have the most advantages, thus, the advice given after this research was to use cameras which make use of the CSI protocol.

Contents

1 Introduction

Measuring the length of an infant after birth is standard practice in many countries. To get an accurate measurement, the knees and the hips have to be pulled straight. This involves excessive handling of the newborn and can, in some cases, even be harmful for future growth. Additionally, premature infants and sick newborns are often kept in incubators where the environment can be controlled. To protect them from infection, these infants need to be handled as little as possible.

An ideal way to measure the length of a newborn infant would be one where they would be handled as little as possible. A group of researchers from Israel have done research on a way to measure infant length with stereoscopy [1]. They have found that their stereoscopic system is accurate and reliable enough to be used and could even work through incubators.

During this project, this existing project will be rebuilt and tested to see how accurate it is. Additionally, it will be tested for use on incubators.

2 Theoretical framework

Communication protocol can be defined as ”A set of rules and regulations that allow two electronic devices to connect to exchange the data with one and another.” [**?**]. Two types of communication protocols can be distinguished: inter system protocols and intra system protocols. Inter system protocols are used to communicate between two different devices, while intra system protocols are used to communicate between devices on the same circuit board [**?**].

Probably the most famous form of inter system communication is USB (universal serial bus), one that will be covered in this report. It is used for both data transfer and power supply in many shapes and on many types of devices such as, but not limited to, mobile phones and other small electronic devices (both charging and data transfer), peripheral devices such as keyboards or mice or data storage in the form of external hard drives or USB drives.

USB would then seem the most obvious choice when searching for a way to communicate between two devices, but there are many more options for communication.

3 Method

The research study will be conducted by means of literature research. Some options for communication that are viable for the project will be selected after which, research will be done on how these technologies work and how they can be implemented into the project.

At last, a comparison will be made of the technologies, so a conclusion can be drawn about the method of communication between controller and cameras best suited for the product.

4 Results

The system will be built on a Raspberry Pi model 3B+ (small computer built on a single circuit board). This limits the options for the communication between the Raspberry Pi and the cameras. The Raspberry Pi has four USB ports and one CSI port [2], so these two protocols shall be looked at and compared. While comparing the different inter system protocols for communication, suitability and quality of the camera itself will not be taken into account.

4.1 USB

USB (Universal Serial Bus) is a widely used industry standard for connection, communication, and power supply for many devices. It uses a four-wire system (power, ground, data+, and data-) and can make four basic types of data transaction [**?**]:

Control Used by the hosts to configure devices and send commands.

Interrupt When a device needs to send small amounts of data which needs to be processed with as little latency as possible such as mice and keyboards.

Bulk When large amounts of data need to be transferred, it gets send in large 'bulk' packages. This is used for devices such as printers or scanners.

Isochronous Continuous and real-rime. Fast delivery of data is ensured at the expense of not checking data and not taking the time to resend failed data packages, resulting in data loss. Is used for devices such as live audio or video.

USB cameras make use of the 'isochronous' type.

The Raspberry Pi that will be used for the project has four USB 2.0 ports. This is sufficient to use two cameras (and still have enough ports left for other needed peripherals) without needing to purchase extra hardware.

4.2 CSI

CSI (camera serial interface) is a high-speed protocol primarily intended for point-to-point image and video transmission between cameras and host devices developed by the Mobile Industry Processor Interface (MIPI) Alliance [3]. Figure 1 shows a diagram explaining how CSI works.

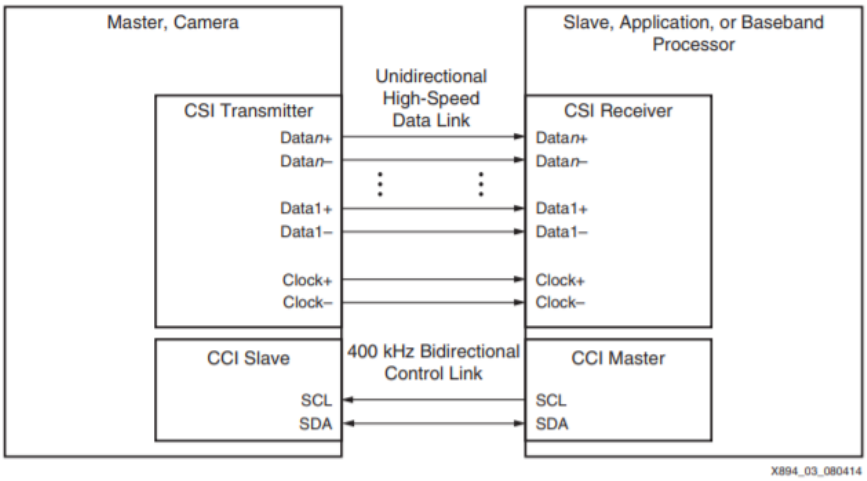

Figure 1: Diagram of CSI [4]

The camera (master) sends one or more bits serially with one clock (signal which oscillates between high and low and is used as a metronome to synchronize actions, as seen in figure 2). CSI only works one direction, so to control the camera, a bidirectional link based on I2C, a communication system consisting of two lines: SDA (data) and SCL (clock) [5], is necessary [4].

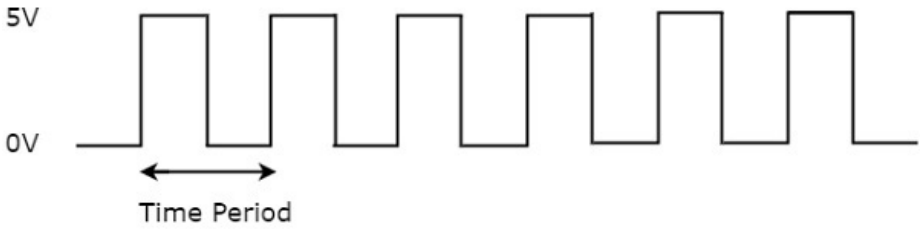

Figure 2: Example of a clock signal [**?**]

CSI is a high-speed protocol. The data is communicated down the data lanes at double the rate as the data is sent on both 'edge' of the clock (both when it goes up and when it goes down instead of just over one time period).

The Raspberry Pi only has one CSI port, while the project requires two cameras. This means a multiplexer (a device that allows you to switch between multiple inputs on a single output line) is required if this protocol is used.

4.3 Comparison

Both USB and CSI cameras are easy to use on the Raspberry Pi. They both just require plugging in the device, installing a program and running them via simple commands. The USB cameras have the advantage over CSI cameras as the Raspberry Pi only has one CSI port over four USB ports. This requires extra hardware.

On the Raspberry Pi, the CSI port is directly connected to the GPU (graphics processing unit) meaning there is only little impact on the CPU (central processing unit) performance. With USB cameras, not only does all the processing fall to the CPU, the data needs to be transferred through the USB bus, which also costs a lot of processing power [**?**].

In table 1, USB and CSI are compared to each other. Note that the results in the table are not objective, but rather relative to each other.

	CSI	USB
CPU usage	Low	High
Speed	High	Low
General price/performance ratio hardware	Cheaper	More expensive
Extra hardware needed?	Yes	No

Table 1: Comparison between options for communications

5 Conclusion and recommendations

For the system to take pictures of an object and process them afterwards, a communication system suitable for controlling two cameras at the same time needed to be found. There are generally many options for communication protocols. This research was conducted to answer the main question: which protocol for communication is best suited for the aforementioned stereoscopy project?

To answer this question, the options for communication had to be narrowed down after which the chosen protocols needed to be compared to come to a conclusion.

The options for inter system communication protocols for the Raspberry Pi were USB and CSI as these are options that can be easily implemented on the Raspberry Pi. Research was condicted to the working of these options, which can be found in the results on page 7. The two protocols were then compared to each other, the result of which can be found in table 1.

When looking at the results, the CSI protocol seems to have more advantages than USB does. CSI is faster and the cameras are relatively cheaper when compared to the quality of the pictures. CSI does have the disadvantage of needing a multiplexer to be able to use two CSI cameras on one Raspberry Pi, but when comparing the other features, it seems the better choice for the project.

Finally, the advice that can be given after this research is to use the CSI protocol and, when making a choice for the cameras that are going to be used, primarily consider cameras using the CSI protocol.

Bibliography

[1] N. Sokolover, M. Phillip, L. Sirota, A. Potruch, N. Kiryati, G. Klinger, and P. Merlob, "A novel technique for infant length measurement based on stereoscopic vision," *Archives of Disease in Childhood*, vol. 99, no. 7, pp. 625–628, 2014. [Online]. Available: https://adc.bmj.com/content/99/7/625

[2] R. P. Foundation, "Raspberry pi 3 model b+," Raspberry Pi Foundation. [Online]. Available: https://www.raspberrypi.org/products/raspberry-pi-3-model-b-plus/

[3] M. Alliance, "Mipi camera serial interface 2 (mipi csi-2)," MIPI Alliance. [Online]. Available: https://mipi.org/specifications/csi-2

[4] A. Taylow, "Microzed chronicles: Working with mipi," 2018. [Online]. Available: https://blog.hackster.io/microzed-chronicles-working-with-mipi-b16b67990ccc

[5] NXP Semiconductors N.V., "I2c-bus specification and user manual," 2014. [Online]. Available: https://www.nxp.com/docs/en/user-guide/UM10204.pdf