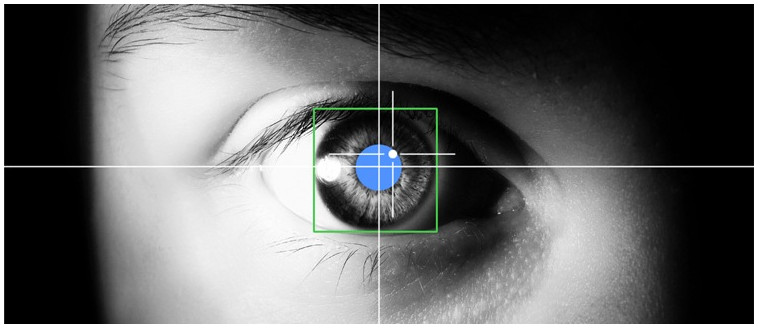
Department of Computer Science & Engineering
The University of Texas at Arlington

Architectural Design Specification
CSE 4316: Senior Design I
Fall 2015



Eyeronic
Eye Tracker

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Revision History

Revision	Date	Author(s)	Description
0.1	11.18.2015	KM , JS , ZA , FN , JT	Created Document

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1 Introduction

This product shall have three layers that work in unison to track the pupil of the user. The three layers in our system are the Software layer, Daughter Board, and the Cypress CX3. THe three layers will be discussed more in the coming sections.

2 System Overview

The system consists of three major layers which are: The Daughter Board Layer, The Cypress CX3 Layer, and the Software Layer. The Daughter board is the main interface between the MIPI camera module and the Cypress CX3. It contains the OmniVision 5640 sensor that interfaces to the cypress CX3. The Cypress CX3 layer provides the interface between the MIPI camera and the USB. This layer is what communicates with the computer and the Daughter board. It uses USB to power the device and transfer the data to a computer. The Software layer takes input from the Cypress Interface, processes that data, and tracks the pupil movement in real time. Various Computer Vision algorithms such as the Canny Edge Detector, Gaussian Smoothing, and the Random Sampling Consensus are implemented by the software layer to accurately track the pupil movement.

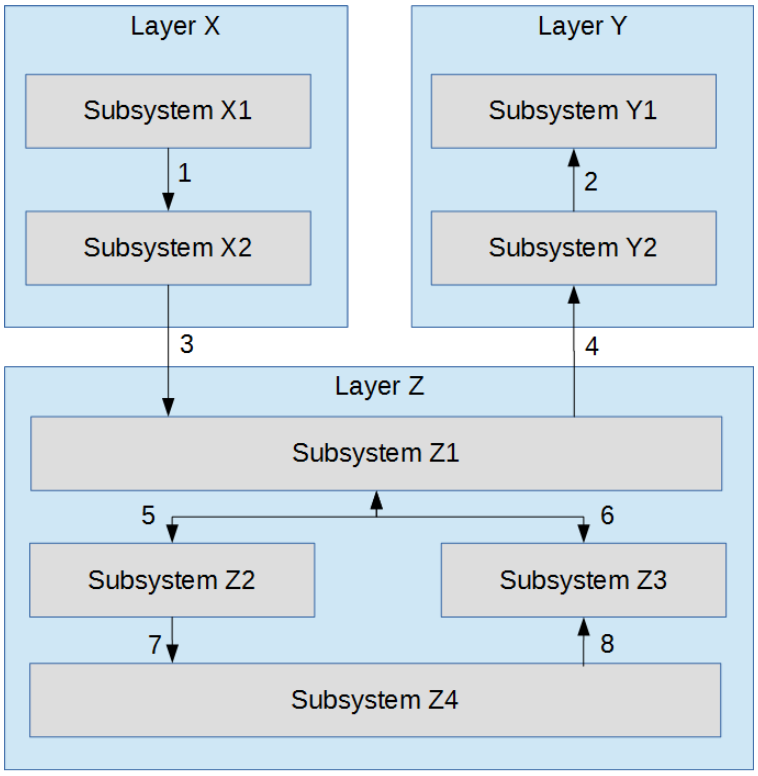

Figure 1: A simple architectural layer diagram

2.1 Software Layer Description

The software layer makes use of the OpenCV library and implements the entire program in C++ language. It consists of three major subsystems. The first subsystem is the Input subsystem. It gets input from the interface provided by the Cypress CX3. A video stream from a device (or a disk for test purposes) is read and stored into a CV::Mat structure. This structure will later be passed onto the processing subsystem. The goal of the processing subsystem is to filter out all the noise (anything but the pupil) and it does so utilizing readily available OpenCV algorithms which shall be discussed in detail later in the document. The final layer is the display layer which gathers information from the processor and displays the final result (fitted elipse) into the original video stream.

2.2 Daughter Board Description

The daughter board is a board that is used to interface between the camera module and the Cypress CX3. This board uses a high-speed rugged ground plane socket (Base BRD Connector) to transfer the data that the camera captures to the CX3. In order for the camera module (pcDuino Camera Module) to function properly the daughter board needed a new camera connector, since the original connector is not compatible. We replaced the old connector with the Panasonic connector (AXK824145WG). The purpose of the new camera connector is to interface the camera with the Base BRD Connector. The daughter board contains the OmniVision 5640 that is interfaced through the 2-lane MIPI interface.

2.3 Cypress CX3 Description

The Cypress CX3 is a MIPI to USB interface. This controller is fully functional with any image sensor that is compliant with a MIPI Camera Serial Interface (OmniVision 5640). The Cypress CX3 is used to control the communication between a computer and the device, since it uses a USB connection to power the device and transfer the data that it collected. Also in order for the device to store the data read from the camera module, it uses EEPROMS in order to prevent loosing data in cases the device looses power. Then the device will transfer its data to the computer via USB. The Cypress CX3 is also connected to the MIPI camera.

3 Subsystem Definitions & Data Flow

The following section shows a high level diagram of all layers of our system.

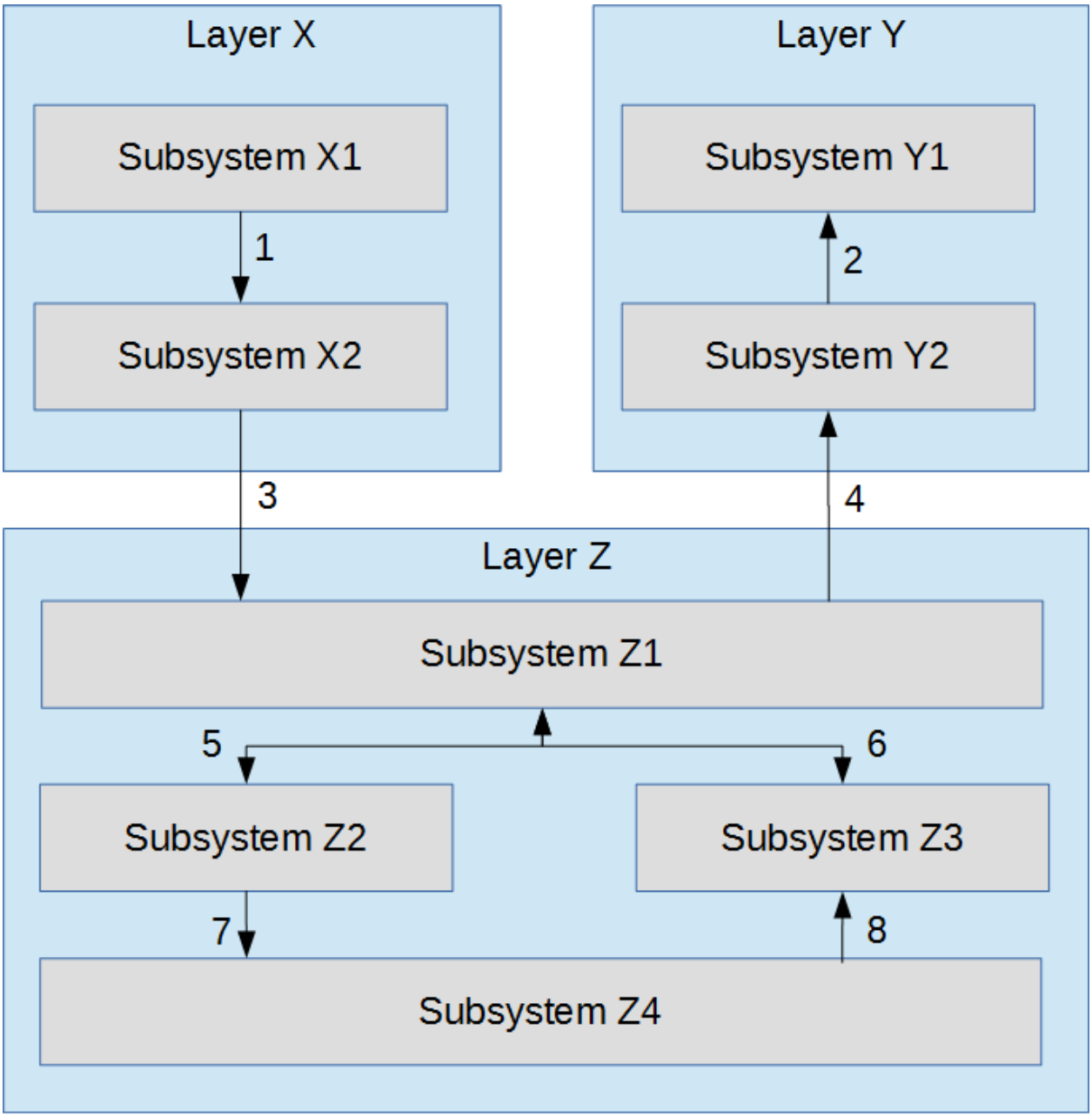

Figure 2: A very complex data flow diagram

4 Software Subsystems

This section discusses the software layer which consists of three major subsystems.

4.1 Input Subsystem

The input subsystem is responsbile for receiving video input and sending it to the processing subsystem.

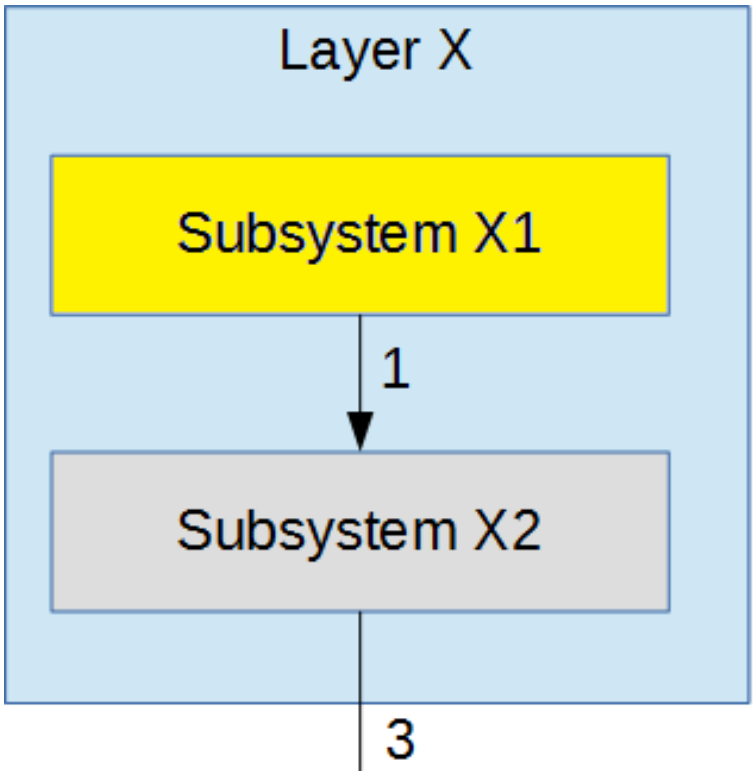

Figure 3: Example subsystem description diagram

4.1.1 Assumptions

We are assuming that we are getting the required video data from the Cypress CX3 or any other USB device. The software is flexible enough to be able to read the data from a file or directly from the hardware.

4.1.2 Responsibilities

This subsystem is responsible for properly receiving the video data and sending it to the processor subsystem.

4.1.3 Subsystem Interfaces

The input could either from a file (for test purposes) or a live stream from the cypress camera. The details are shown in the table.

Table 2: Subsystem interfaces

ID	Description	Inputs	Outputs
#01	Receive video data	From Cypress Camera From Disk	Video data

4.2 Processor Subsystem

The processor subsystem takes in the video input, processes it sends the processed data to the Track and Display subsystem.

4.2.1 Assumptions

We assume that we are getting video data from the Input Subsystem at 30 frames per second.

4.2.2 Responsibilities

The processor is responsible for utilizing various computer vision algorithms to properly track the pupil. First, the processor needs to smooth each frame in the video. Next, it needs to apply the canny edge detector to detect all the edges. Finally, this processor sends all the detected edges to the Track and Display subsystem.

4.2.3 Subsystem Interfaces

This subsystem gets input of video data and output of a somewhat refined video data.

Table 3: Subsystem interfaces

ID	Description	Inputs	Outputs
#01	Process Video Frames	Video Data	Detected Edges

4.3 Track and Display Subsystem

This subsystem receives some video data whose edges have been detected by the processor subsytem and it tracks and displays the results.

4.3.1 Assumptions

We assume that this subsystem recieves frames whos edges have been detected.

4.3.2 Responsibilities

This subsystem is responsible for applying the pupil tracking algorithm to the input it receives. It then applies the RANSAC algorithm to fit an ellipse to the pupil. Finally, it displays the video with tracked pupil.

4.3.3 Subsystem Interfaces

This subsystem receives edges that were detected by the processing subsystem and outputs the final results in a video stream.

Table 4: Subsystem interfaces

ID	Description	Inputs	Outputs
#01	Receive data and display	Detected Edges	Tracked Eye

5 Daughterboard Subsystems

5.1 Subsystem 1

This section should be a general description of a particular subsystem for the given layer. For most subsystems, an extract of the architectural block diagram with data flows is useful. This should consist of the subsystem being described and those subsystems with which it communicates.

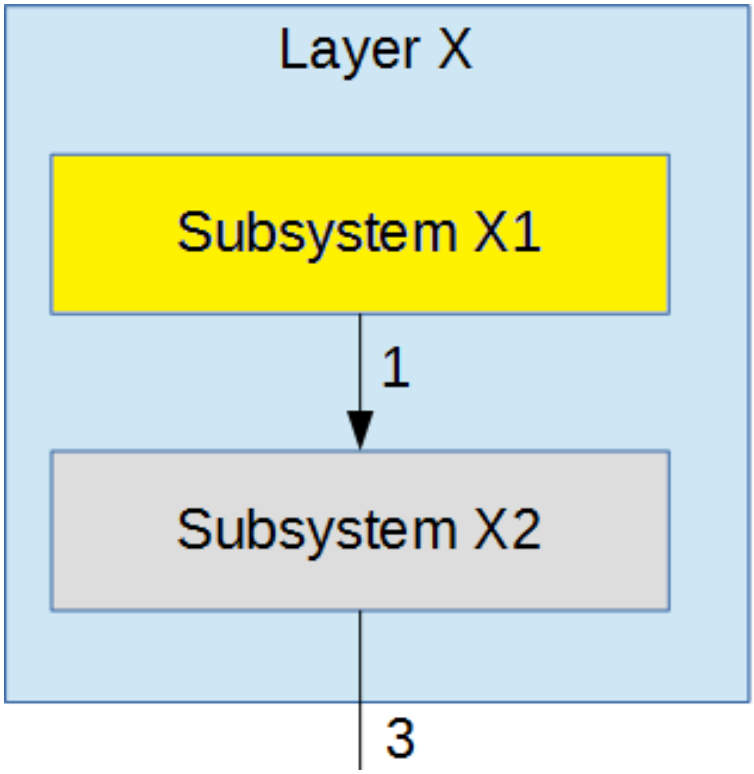

Figure 4: Example subsystem description diagram

5.1.1 Assumptions

Any assumptions made in the definition of the subsystem should be listed and described. Pay particular attention to assumptions concerning interfaces and interactions with other layers.

5.1.2 Responsibilities

Each of the responsibilities/features/functions/services of the subsystem as identified in the architectural summary must be expanded to more detailed responsibilities. These responsibilities form the basis for the identification of the finer-grained responsibilities of the layer's internal subsystems. Clearly describe what each subsystem does.

5.1.3 Subsystem Interfaces

Each of the inputs and outputs for the subsystem are defined here. Create a table with an entry for each labelled interface that connects to this subsystem. For each entry, describe any incoming and outgoing data elements will pass through this interface.

Table 5: Subsystem interfaces

ID	Description	Inputs	Outputs
#xx	Description of the interface/bus	input 1 input 2	output 1
#xx	Description of the interface/bus	N/A	output 1

5.2 Subsystem 2

Repeat for each subsystem

5.3 Subsystem 3

Repeat for each subsystem

6 Cypress CX3 Subsystems

In this section, the layer is described in some detail in terms of its specific subsystems. Describe each of the layers and its subsystems in a separate chapter/major subsection of this document. The content of each subsystem description should be similar. Include in this section any special considerations and/or trade-offs considered for the approach you have chosen.

6.1 Subsystem 1

This section should be a general description of a particular subsystem for the given layer. For most subsystems, an extract of the architectural block diagram with data flows is useful. This should consist of the subsystem being described and those subsystems with which it communicates.

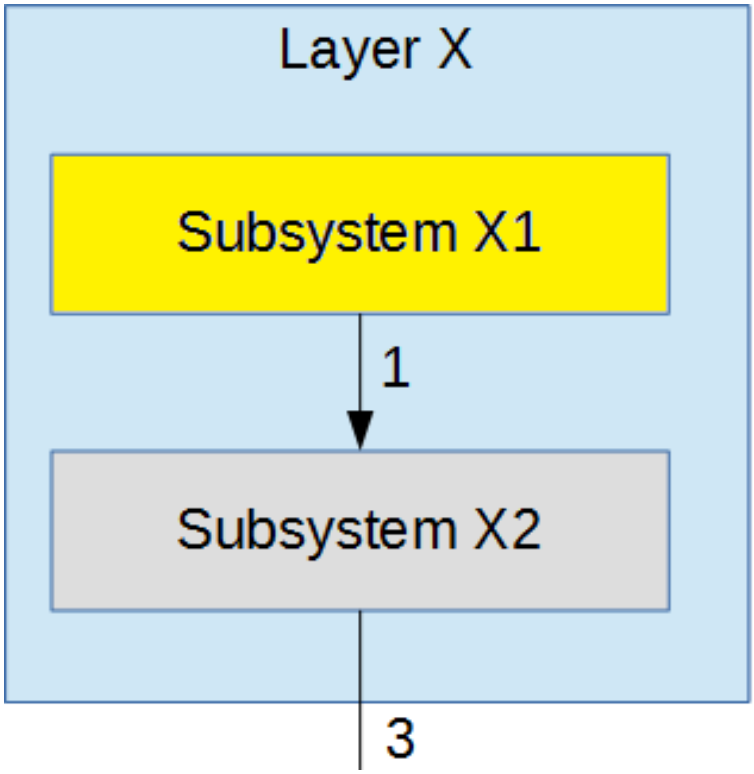

Figure 5: Example subsystem description diagram

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6.2 Subsystem 2

Repeat for each subsystem

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Repeat for each subsystem