3D Head Pose Demo for CrossLink-NX Devices

User Guide

FPGA-UG-02199-1.0

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This document was created consistent with Lattice Semiconductor’s inclusive language policy. In some cases, the language in underlying tools and other items may not yet have been updated. Please refer to Lattice’s inclusive language FAQ 6878 for a cross reference of terms. Note in some cases such as register names and state names it has been necessary to continue to utilize older terminology for compatibility.

Contents

Figures

Tables

Acronyms in This Document

A list of acronyms used in this document.

Acronym	Definition
FPS	Frames per second
SPI	Serial Peripheral Interface

1. Introduction

In the ever-evolving landscape of computer vision and facial recognition technologies, the Lattice sensAI™ Solution Stack presents a cutting-edge approach to 3D head pose solution. The 3D head pose solution aims to revolutionize human face detection by not only identifying facial features but also providing detailed parameters essential for a comprehensive understanding of facial orientation.

This document describes the steps to run the 3D head pose demo on the Lattice CrossLink™-NX Voice and Vision Machine Learning Board connected to PC. To run this demo, connect one USB port on your laptop to connector J2 (USB Micro-B connector) using USB-A to USB 2 Micro-B cable and second USB port to connector J8 (USB Micro-B super speed) using USB-A to Micro-B super speed cable. On the PC, open the 3D Head Pose GUI application to run the demo. Figure 1.1 shows the 3D head pose demo setup.

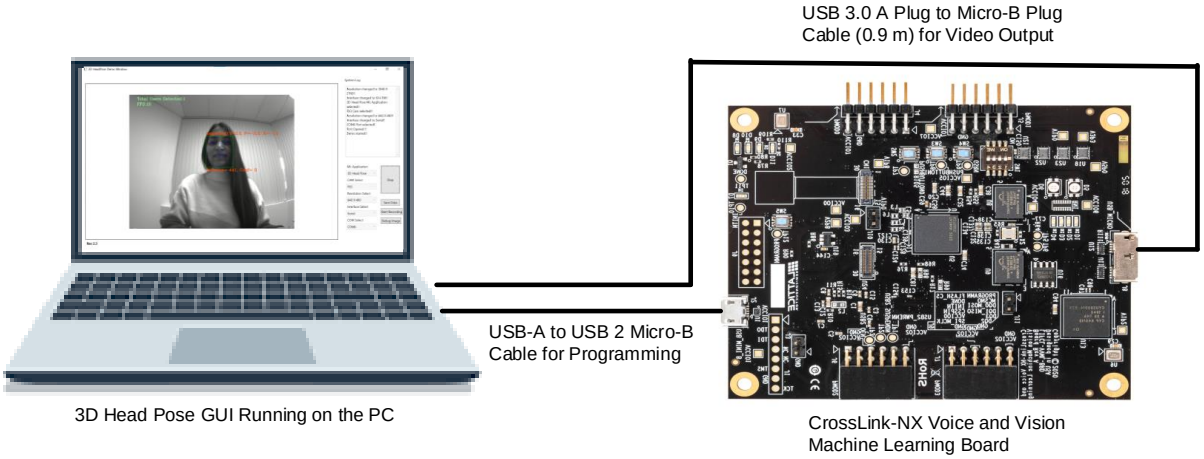

Figure 1.1. 3D Head Pose Demo Setup

2. Demo Requirements

2.1. Hardware Requirements

The hardware requirements for the demonstration using the Lattice sensAI Solution Stack are as follows:

- CrossLink-NX Voice and Vision Machine Learning Board (LIFCL-VVML-EVN). For more details of the board, refer to the CrossLink-NX Voice and Vision Machine Learning Board User Guide (FPGA-EB-02039).
- USB-A to USB 2 Micro-B cable for programming the board.

Figure 2.1. USB Micro-B Cable

- USB 3.0 A plug to USB Micro-B super speed plug cable (0.9 m) for video output

Figure 2.2. USB Micro-B Super Speed Cable

2.2. Hardware Setup

To setup for this demo, follow these steps:

1. Connect the USB-A to USB 2 Micro-B cable to the J2 pin of the CrossLink-NX Voice and Vision Machine Learning Board and the PC. This connection provides the meta data and is also used for programming the board.
2. Connect the USB 3.0 A plug to USB Micro-B super speed cable to connector J8 of the CrossLink-NX Voice and Vision Machine Learning Board and the PC. This connection gives video output to the PC, where you run the GUI and monitor the data.

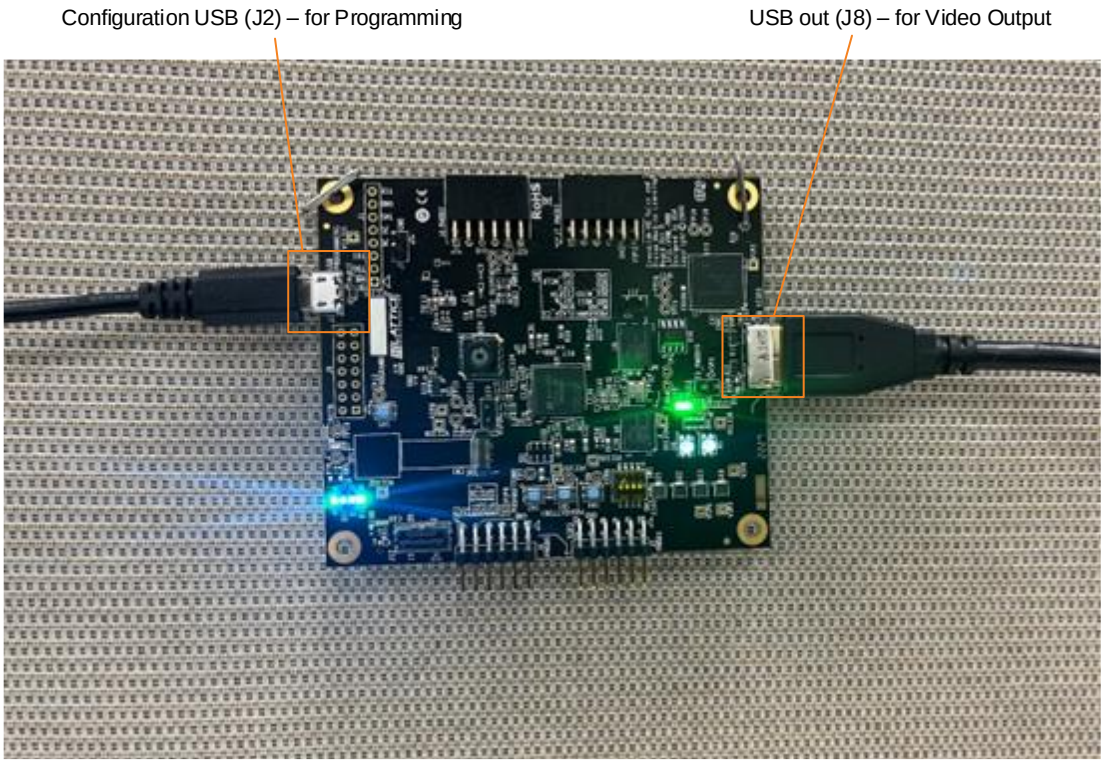

Figure 2.3. Hardware Setup

2.3. Software Requirements

The software requirements for this demo are as follows:

- 3D HeadPose GUI
- The Lattice Radiant™ Programmer software

3. 3D Head Pose Bitstream Programming

3.1. CrossLink-NX Voice and Vision Machine Learning Board Programming

You can program the CrossLink-NX Voice and Vision Machine Learning Board with USB through the FTDI/JTAG interface using the Lattice Radiant Programmer software.

Figure 3.1 shows the programming setup of the CrossLink-NX Voice and Vision Machine Learning Board.

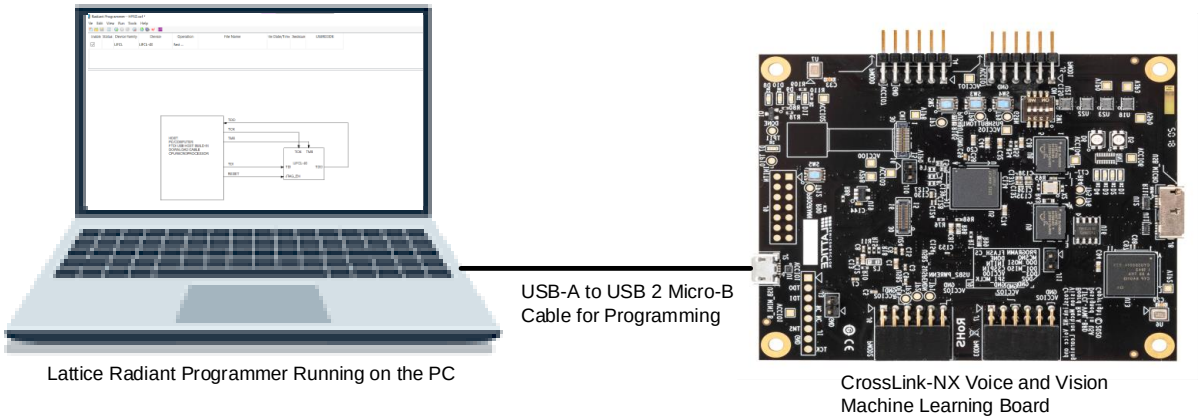

Figure 3.1. Programming Setup

3.2. Programming on Board SPI Flash

This section describes the steps for programming the demo bitstream into the serial peripheral interface (SPI) flash (non-volatile) memory of the CrossLink-NX Voice and Vision Machine Learning Board.

You can program the board using the Lattice Radiant Programmer software, which can be started as a stand-alone tool or from a Lattice Radiant project.

To program the board, follow these steps:

1. Power ON the CrossLink-NX Voice and Vision Machine Learning Board.
2. Launch Programmer from the Lattice Radiant software by clicking **Tools** > **Programmer**.
3. After the Programmer is launched, the **Getting started** window opens. Select **Create a new project from a scan** when the board is connected to PC, as shown in Figure 3.2.

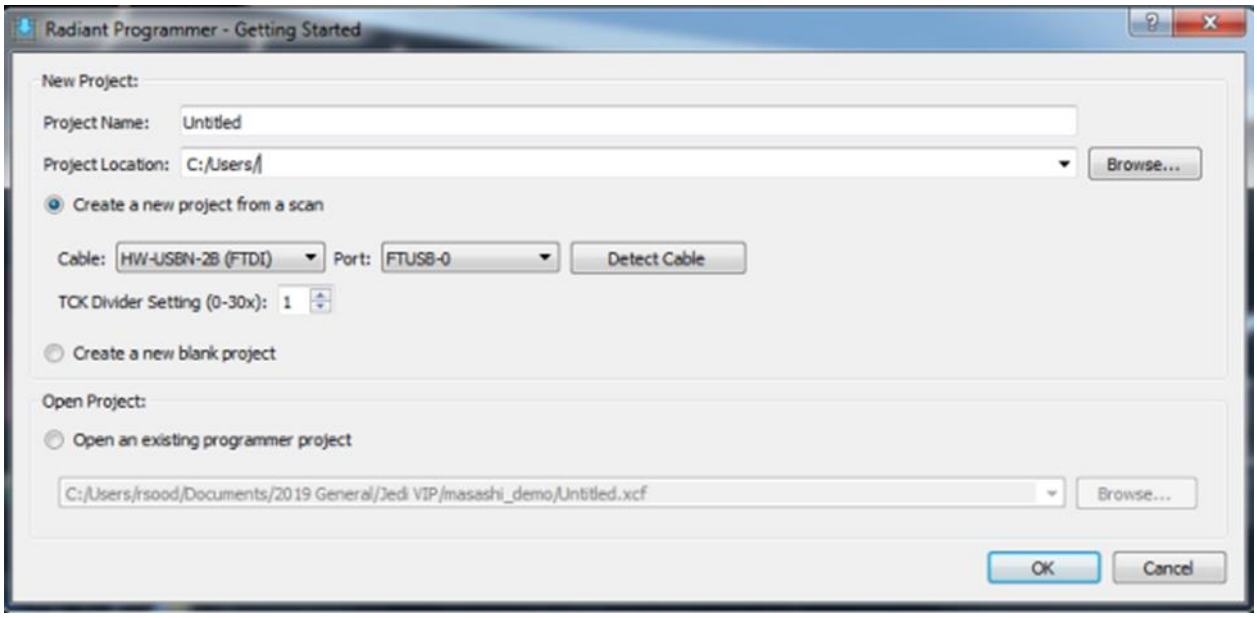

Figure 3.2. Starting the Lattice Radiant Programmer Software

4. When the board is successfully scanned, the **Radiant Programmer** window shows the CrossLink-NX device (LIFCL-40) in the **Device** column, as shown in Figure 3.3.

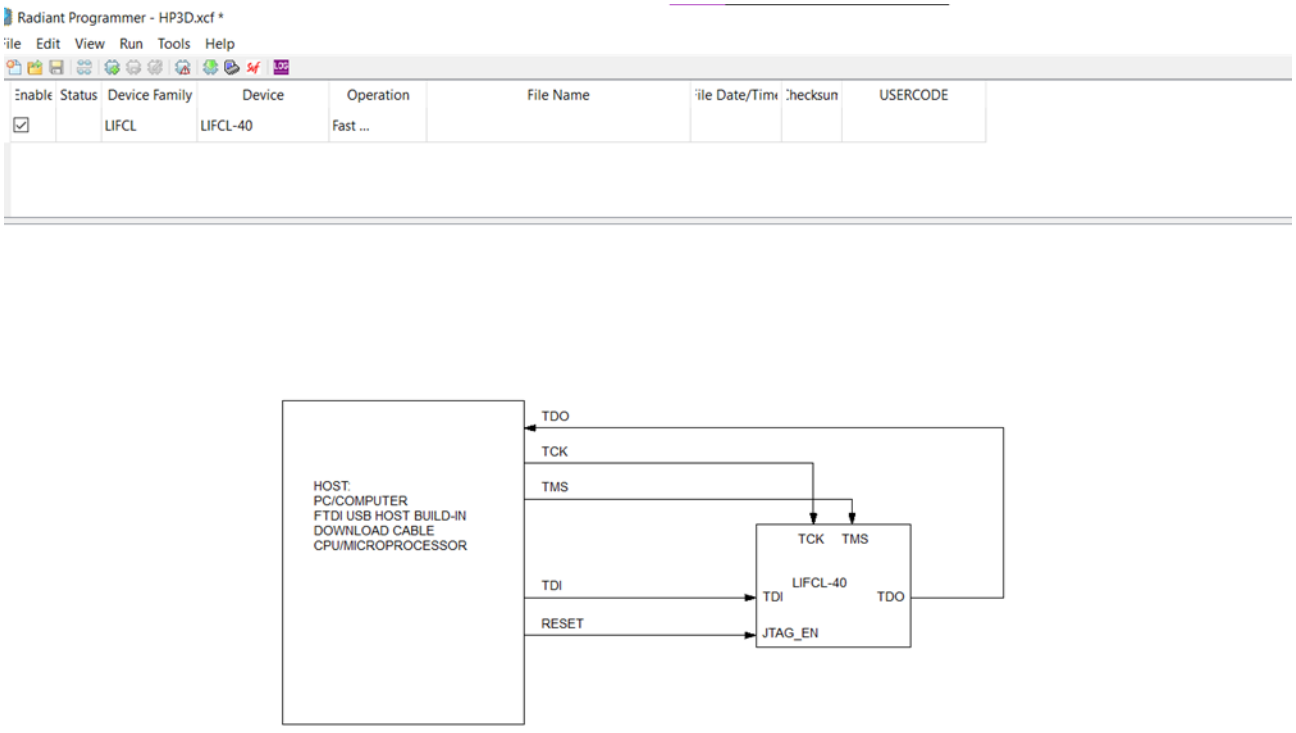

Figure 3.3. Successful Scanning of the CrossLink-NX Voice and Vision Machine Learning Board

5. Double click the operation field. In the **Device Properties** window, select the options to program the SPI flash, as shown in Figure 3.4. Ensure to select the correct Target Memory, Port Interface, and SPI Flash Options. Click OK.

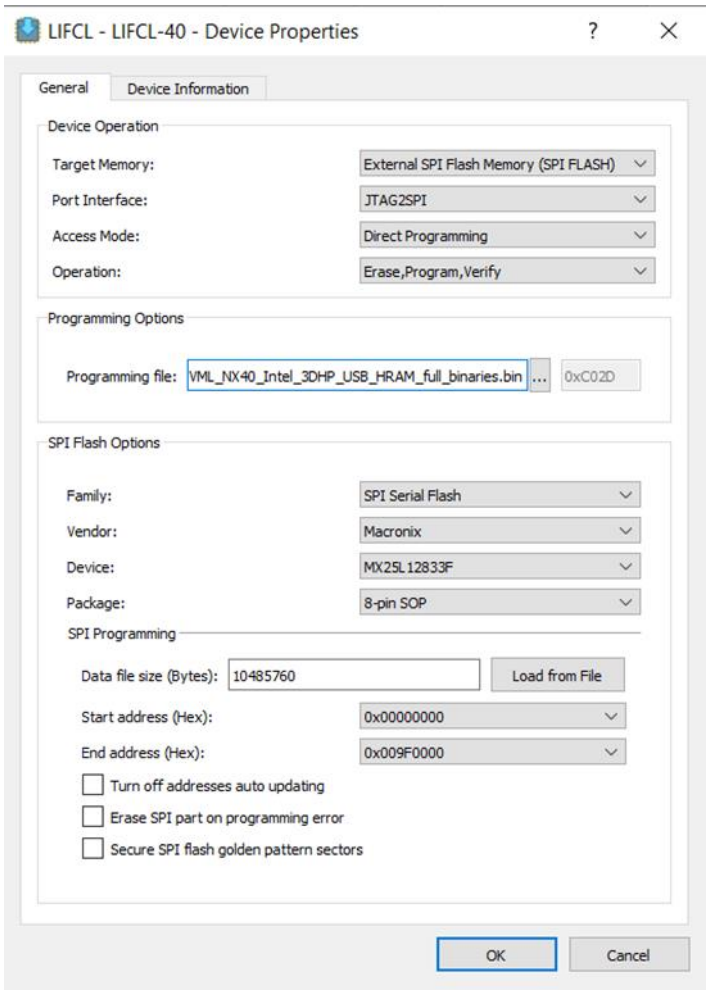

Figure 3.4. Setting Up the Devices in the Lattice Radiant Programmer Software

6. To configure the CrossLink-NX device on the board, click Program Device as shown in Figure 3.5.

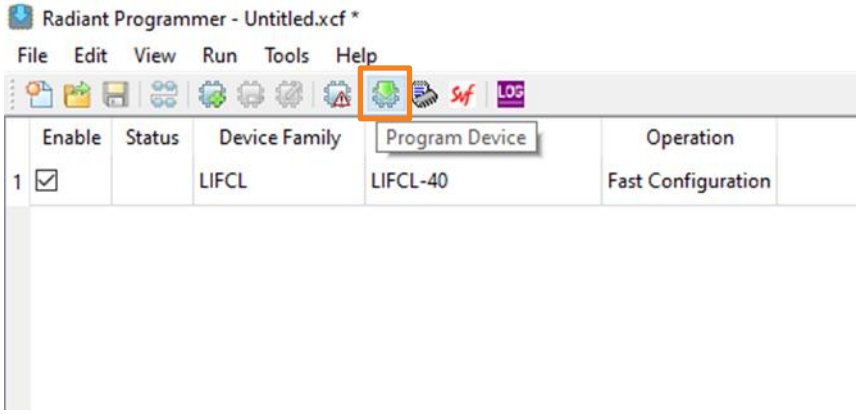

Figure 3.5. Program Device in the Lattice Radiant Programmer Software

4. 3D Head Pose Demo Application

You can run the 3D head pose demo using the demo application GUI. To setup and run the demo using the GUI, follow these steps:

1. Open the *3D_HeadPose_Demo.exe* file in the 3D HeadPose Demo package.

Figure 4.1. 3D_HeadPose_Demo GUI

2. For **ML Application**, select **3D Head Pose**.

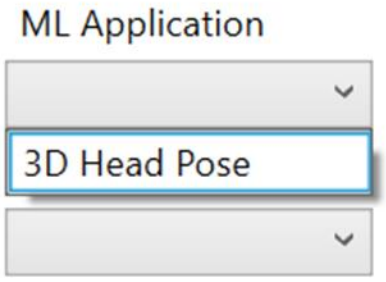

Figure 4.2. ML Application Drop-down Options

3. For **CAM Select**, select **FX3** for this demo. The FX3 camera refers to the Cypress FX3 SuperSpeed USB 3.0 controller for video output.

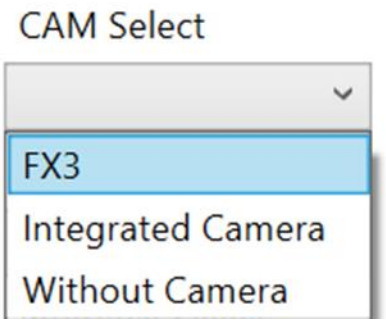

Figure 4.3. Camera Drop-down Options

4. For **Resolution Select**, select **640 X 480** for this demo.

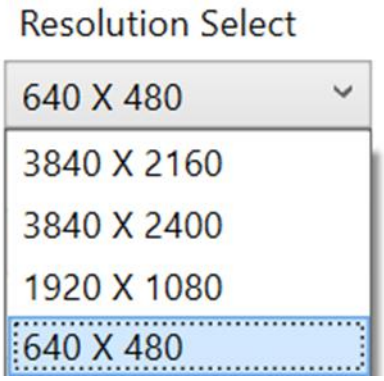

Figure 4.4. Resolution Select Drop-down Options

5. For **Interface Select**, select **Serial** for this demo. You can interact with the 3D HeadPose GUI using the serial interface.

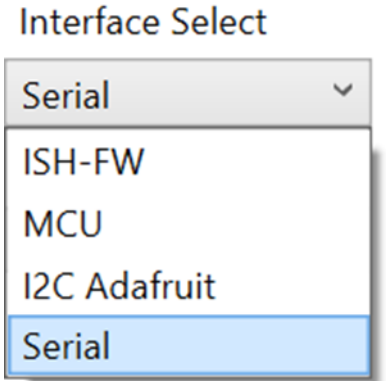

Figure 4.5. Interface Select Drop-down Options

6. **COM Select** shows up in the GUI after selecting **Serial** for **Interface Select**. Figure 4.6 shows an example of the **COM Select** options. Select the COM port with a higher number in the options.

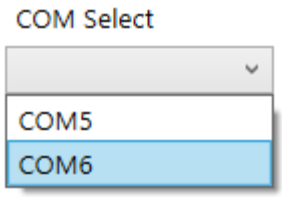

Figure 4.6. COM Select Drop-down Options

7. Check and ensure you select the correct options for the 3D HeadPose demo, as shown in Figure 4.7.

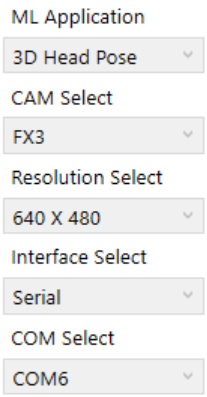

Figure 4.7. Properties for the GUI

8. To run the demo, place the board vertically in front of you and click **Demo**.

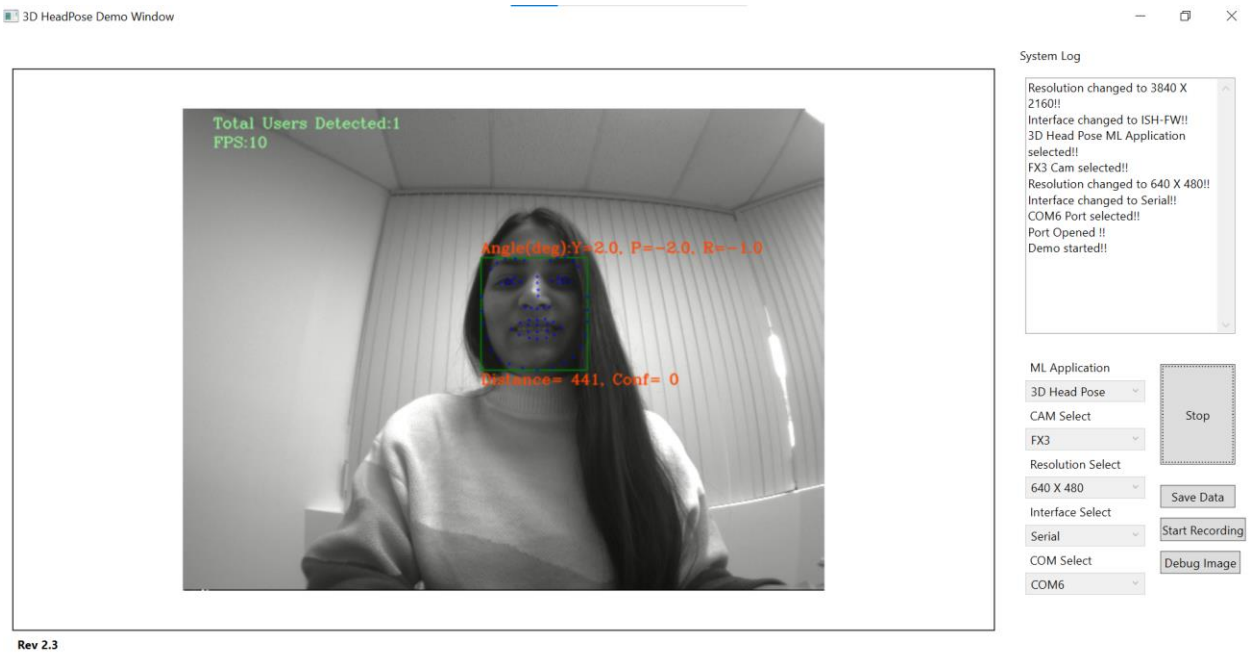

Figure 4.8. Running the 3D_HeadPose_Demo Using GUI

5. 3D Head Pose Demo Application Features

The 3D Head Pose Application GUI shows the camera output and the detected human with face landmarks showcasing the key facial markers and orientation on the screen. The demo window has various parameters. The following sections describe the parameter details on the demo screen.

5.1. Total Users Detected

The demo can detect more than one human face and record the number of faces detected, as shown in Figure 5.1.

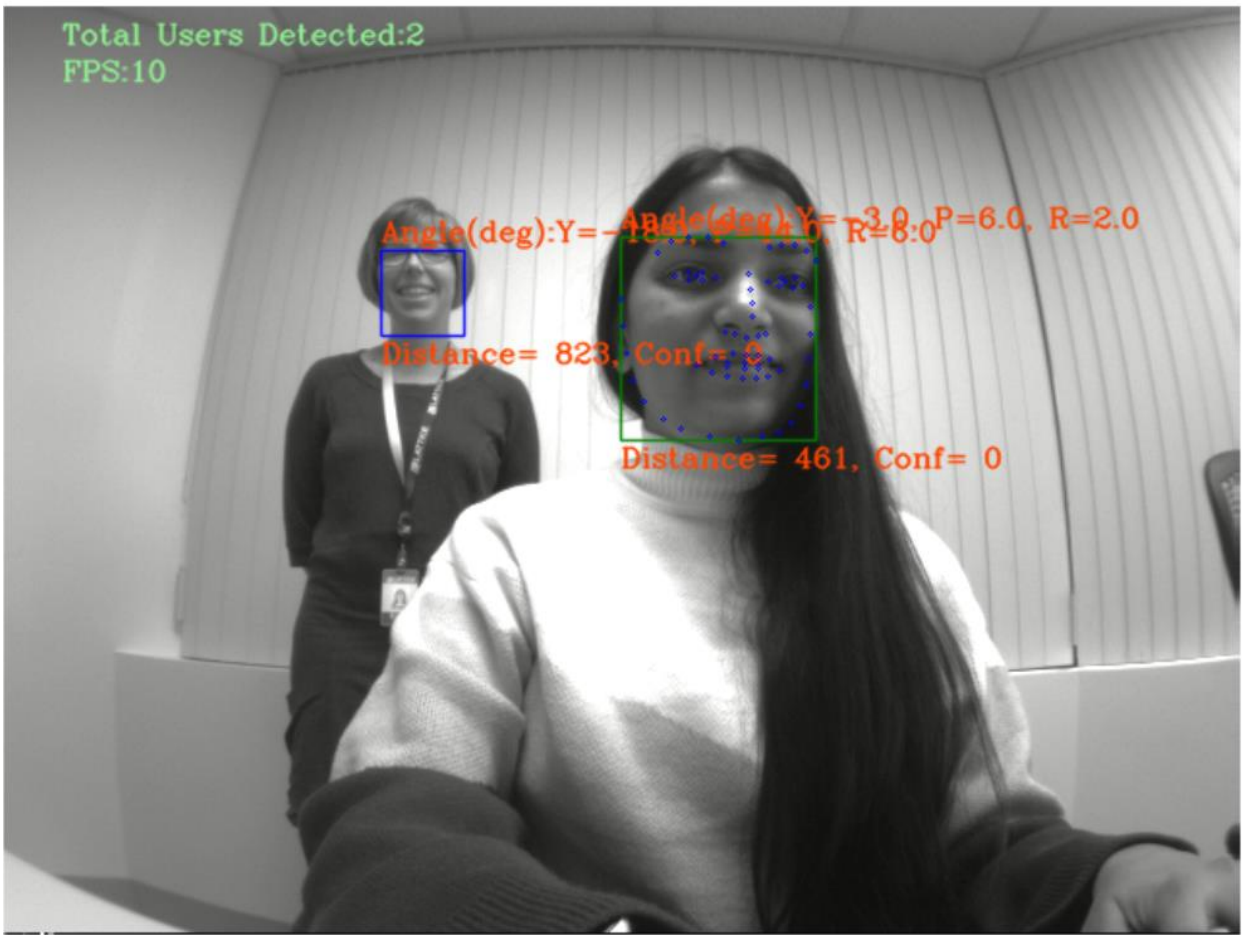

Figure 5.1. Multiple Human Faces Detected

5.2. FPS

Frames per second (FPS) represents the number of individual frames or images that the system can process and analyze in one second. In this demo, a higher FPS indicates that the system can analyze a greater number of frames in real-time, providing faster and more responsive results. If you are not able to completely capture your face, the number of FPS decreases according to the visibility of the human face. Figure 5.2 shows the FPS value on the demo window.

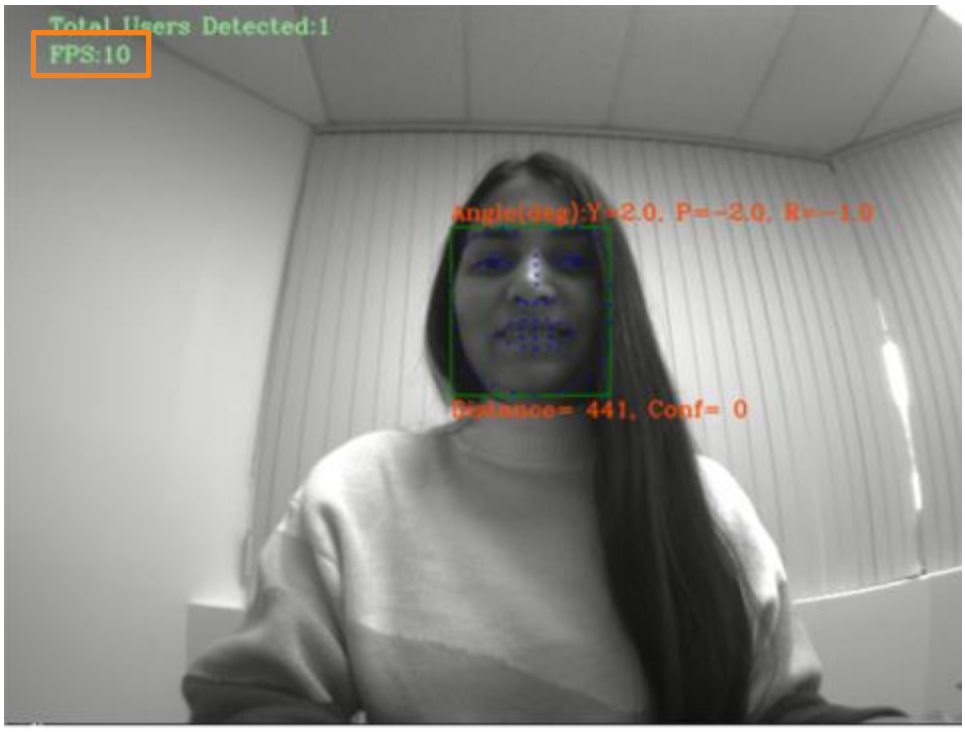

Figure 5.2. FPS on the Demo Window

5.3. Bounding Box

Bounding box is a box generated around the detected face. If multiple faces are detected, each face has a bounding box of different color. Figure 5.3 shows a green bounding box around the detected face.

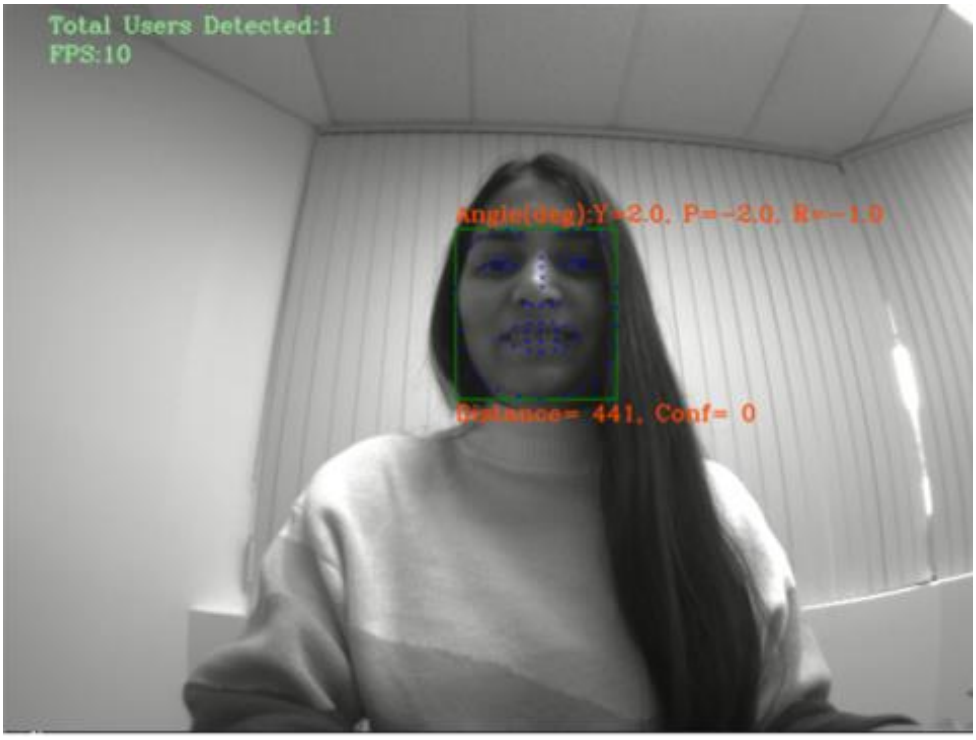

Figure 5.3. Bounding Box Generated Around the Detected Face

5.4. Angle(deg): Y, P, and R

Figure 5.4 shows the overall angle parameters (Y, P, R) to Indicate the orientation of the face.

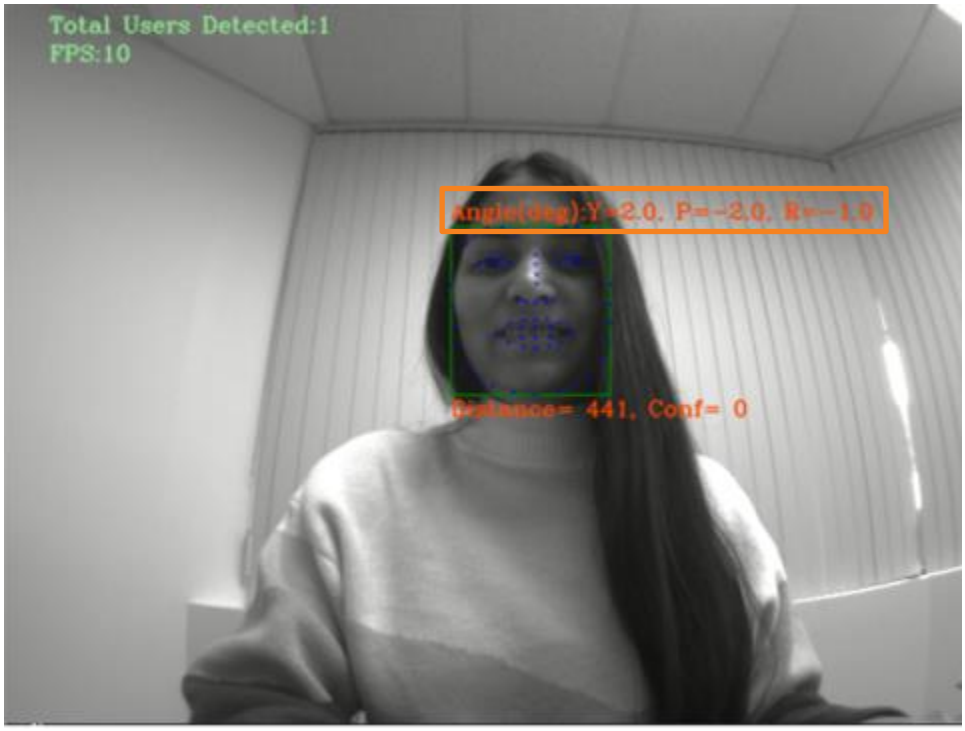

Figure 5.4. Overall Parameters (Y, P, R) to Indicate the Orientation of the Face

5.4.1. Yaw (Y)

Yaw refers to the rotation of an object along the vertical axis. In this demo, Yaw refers to the horizontal rotation or swiveling of the head from side to side, changing the direction in which the head is facing without tilting up or down. When you turn your head to the left, the Y value decreases; when you turn your head to the right, the Y value increases. Figure 5.5. shows the change in Y value as you turn your head to the right.

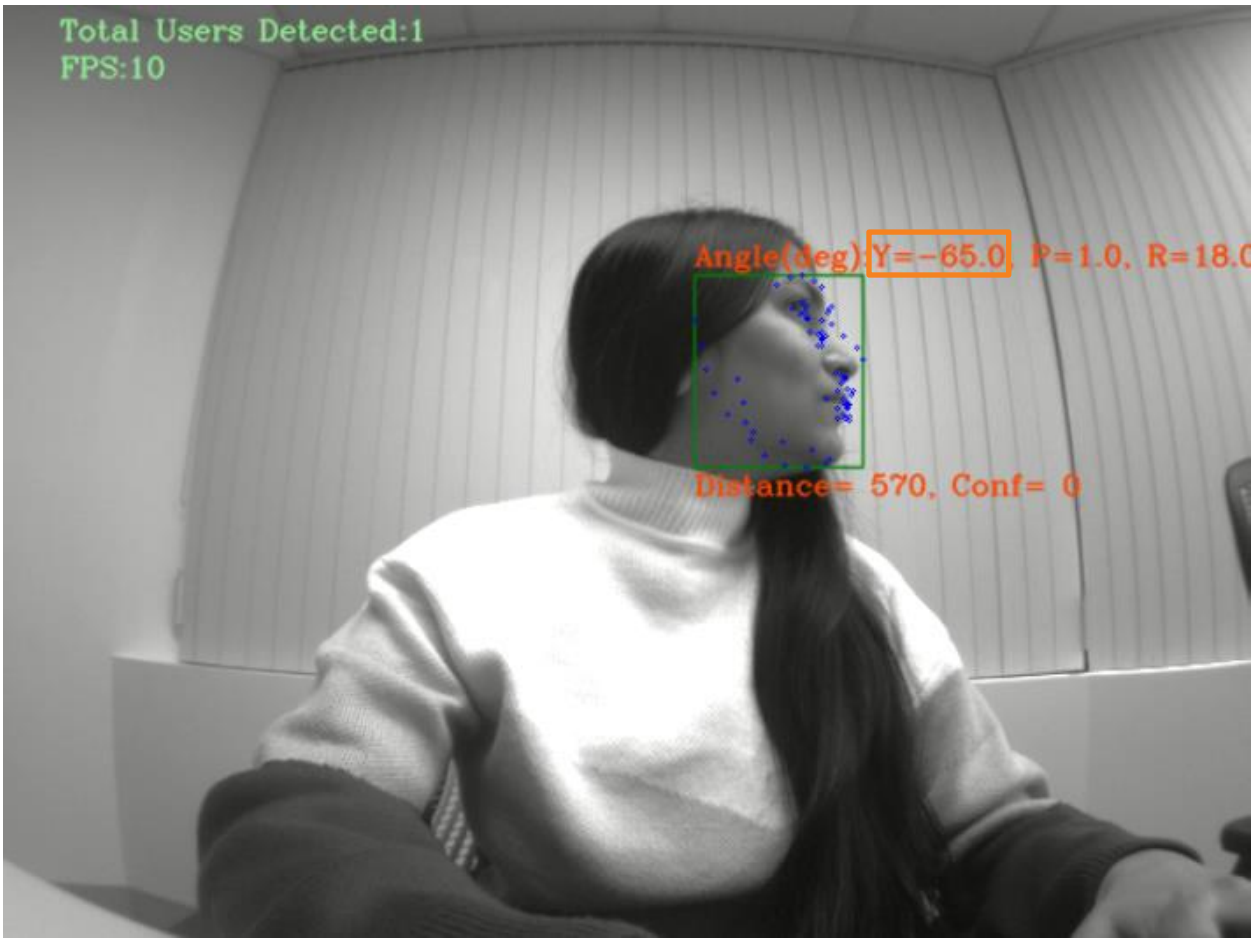

Figure 5.5. Change in Y Value

5.4.2. Pitch (P)

Pitch refers to the rotation of an object around the horizontal axis. In this demo, Pitch refers to the nodding of the head or vertical tilting, which changes the angle at which the head is facing up or down without changing the side-to-side orientation. The P value increases as you turn your head upward; the P value decreases as your turn your head downward. Figure 5.6. shows the change in P value as you look upward.

Figure 5.6. Change in P Value

5.4.3. Roll (R)

Roll refers to the rotation of an object around the longitudinal axis or front-to-back axis. In this demo, roll refers to the side-to-side tilting. When your head rolls, you tilt your head to one side and return your head to an upright position. The R value increases as you tilt your face to the right; the R value decreases as you tilt your face to the left. Figure 5.7. shows the change in R value as you tilt your face to the left.

Figure 5.7. Change in R Value

5.5. Distance

The Distance value is calculated by the distance of the detected face from the camera with respect to the x, y, and z spatial coordinates of the camera. Distance increases as the detected face goes far away from the camera and decrease as the detected face comes closer to the camera. Figure 5.8 shows the value of the Distance parameter on the demo window.

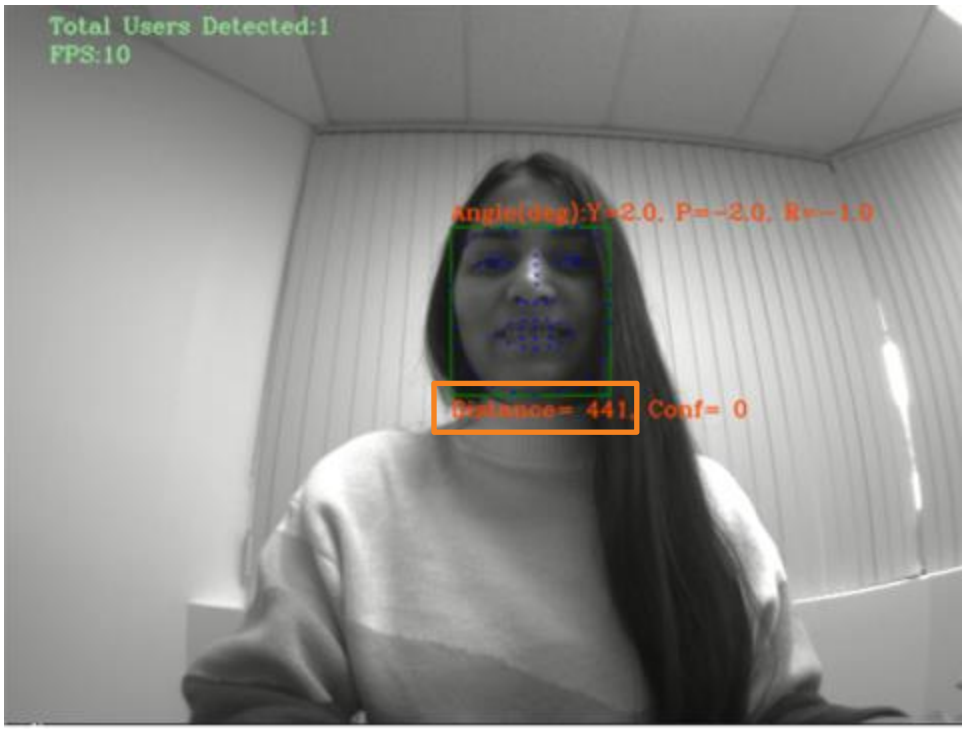

Figure 5.8. Distance Parameter on the Demo Window

5.6. Confidence

The Conf value is the confidence level of the system in accurately detecting and identifying the face, providing insights into the reliability of the recognition. Figure 5.9 shows the value of the Conf parameter on the demo window.

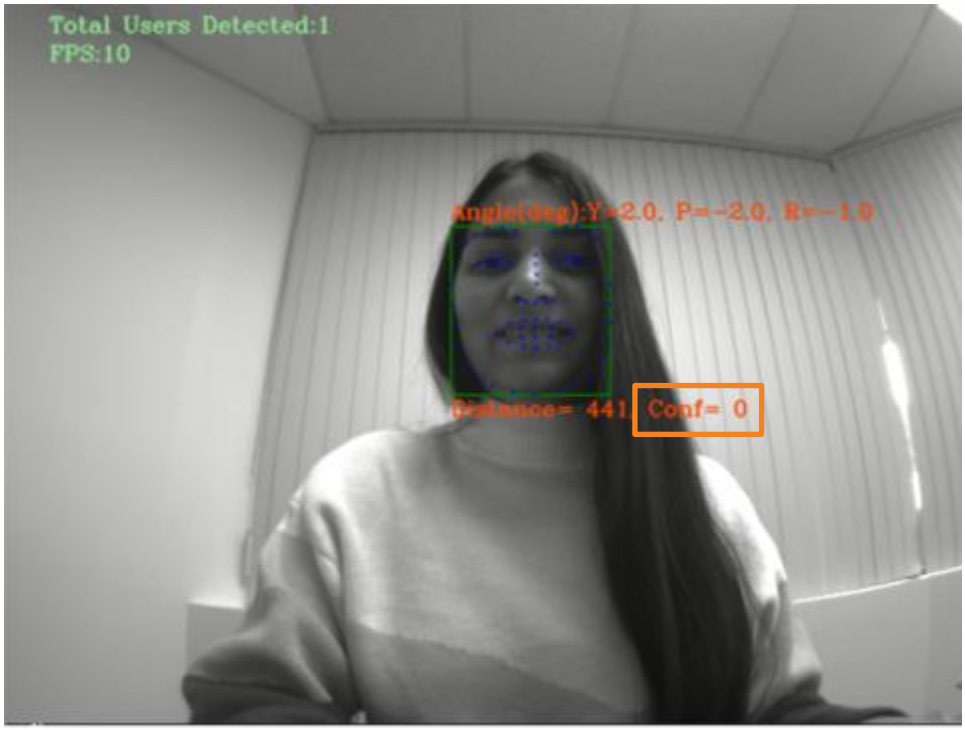

Figure 5.9. Confidence Parameter on the Demo Window

5.7. Face Landmarks

Face landmarks are the blue dots around the key facial features, like eyebrows, eyes, nose, lips, and jawline When the face is detected, the demo window displays blue dots around the key facial features. Figure 5.10 shows the face landmarks located around the key facial features.

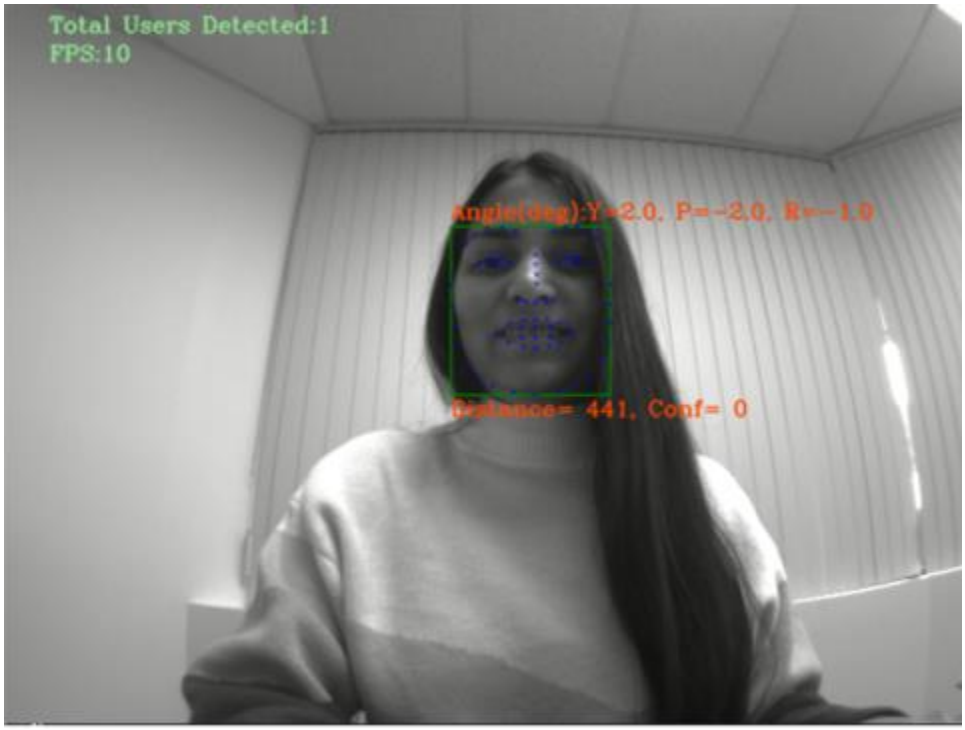

Figure 5.10. Face Landmarks Located Around the Key Facial Features

Appendix A – Debugging

A.1. Saving the Current Frame Data (Save Data)

To capture the current frame in the video window, click **Save Data** on the application GUI, as shown in Figure A.1. The **record** folder is automatically created within the same folder where the .exe file is located. The image is automatically saved in the **record** folder.

Figure A.1. Save Data on the GUI

Figure A.2 shows the example of saved current frame image files using the GUI.

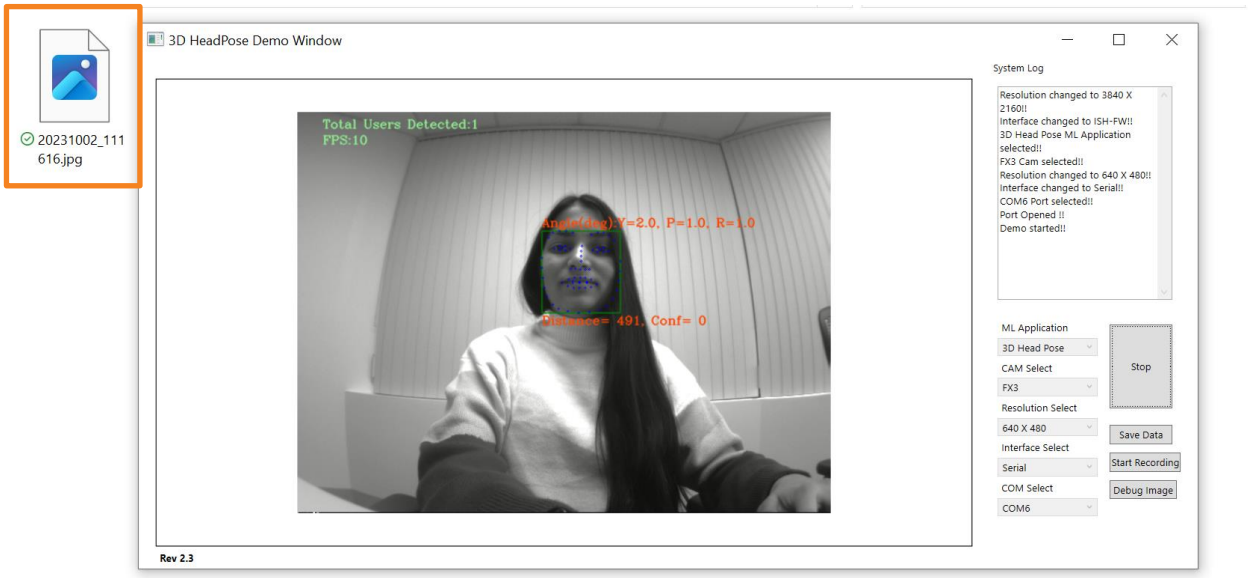

Figure A.2. Example of Saved Current Frame Image of the Demo

A.2. Recording the Video Frame Data (Start Recording)

To record and track the data from the video frame, click **Start Recording** on the application GUI, as shown in Figure A.3. The application records the video until you click **Stop Recording**. The recorded video is saved in the folder where the .exe file is located.

Figure A.3. Start Recording on the GUI

There are two types of recordings: original recording and result recording. Original recording has the recorded video without the bounding box and other data. Result recording shows the bounding box around the detected face and contains the properties of the face capturing with respect to the movement of the face.

Figure A.4 shows the example of the recorded video using the GUI.

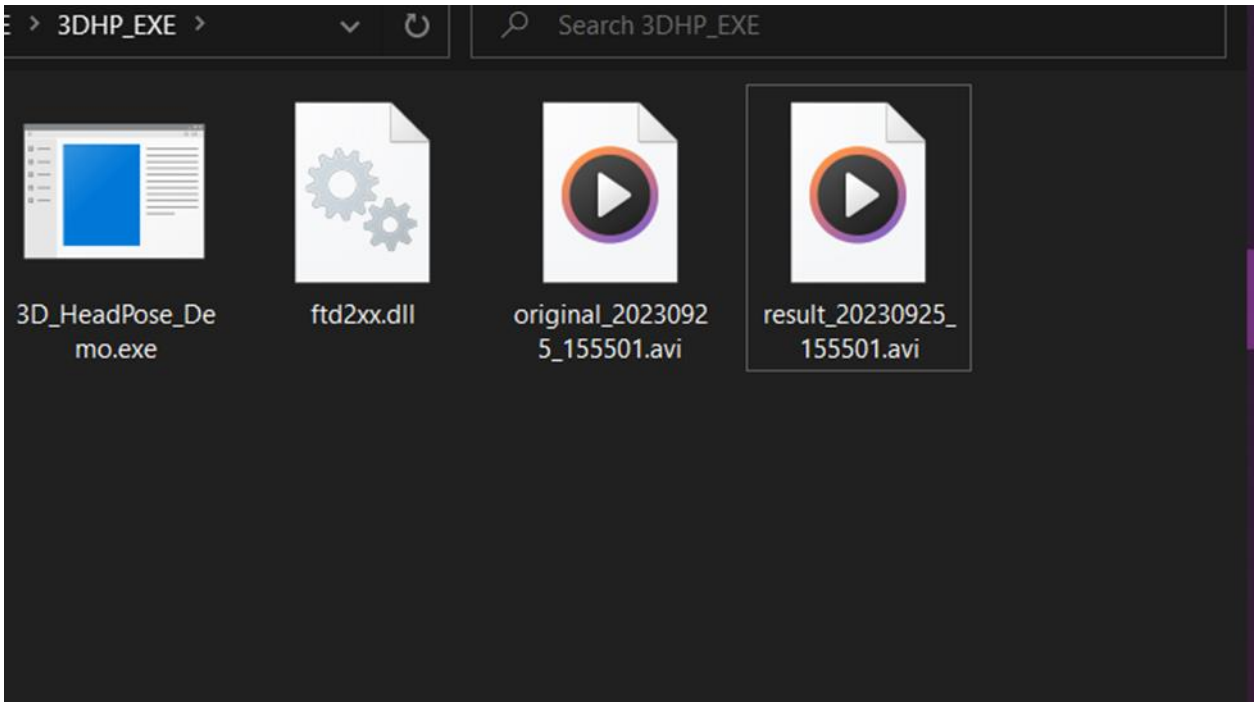

Figure A.4. Example of Saved Video Recordings of the Demo

Appendix B – Troubleshooting

- Hold the CrossLink-NX Voice and Vision Machine Learning Board vertically before running the demo. You are not able to start the demo if you hold the board horizontally.
- The demo works well in good lighting conditions. The performance of demo is impacted if lighting conditions are not optimal.
- If the System log shows the message 'Serial connection not sending', reconnect both cables before you start the demo. The system requires some time to setup and start the connection between the board and the application.
- If the USB Micro-B super speed cable is not connected properly, the GUI is unable to show the **FX3** option in **CAM Select**. Reconnect this cable to the board and PC.
- The accuracy of face detection depends on distance and lighting conditions. Table B.1 shows the face detection ability for different conditions.

Table B.1. Face Detection for Different Distance and Lighting Conditions

Distance (in inches)	Lighting Condition	Detection Successful	Parameters Detected
10	Bright	Yes	Yes
20	Bright	Yes	Yes
30	Bright	Yes	Yes
40	Bright	Yes	Yes
50	Bright	Yes	Yes
60	Bright	Yes	No
65	Bright	No	No
10	Dark	Yes	Yes
20	Dark	Yes	Yes
40	Dark	Yes	No
45	Dark	No	No

Reference

- CrossLink-NX Voice and Vision Machine Learning Board User Guide (FPGA-EB-02039)
- CrossLink-NX FPGA web page
- Lattice Radiant Software web page
- Lattice sensAI Stack web page
- Lattice Insights for Lattice Semiconductor training courses and learning plans

Technical Support Assistance

Submit a technical support case through www.latticesemi.com/techsupport.

For frequently asked questions, refer to the Lattice Answer Database at www.latticesemi.com/Support/AnswerDatabase.

Revision History

Revision 1.0, December 2023

Section	Change Summary
All	Initial release.

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