Lattice sensAI Edge Vision Engine Tool

User Guide

FPGA-UG-02230-1.1

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Inclusive Language

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.

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Abbreviations in This Document

A list of abbreviations used in this document.

Abbreviation	Definition
3DHP	3-Dimensional Head Position
CPU	Central Processing Unit
DMS	Driver Monitoring System
EVE	Edge Vision Engine
GPU	Graphics Processing Unit
HMI	Human Machine Interface
IR	Infrared
NPU	Neural Processing Unit
RGB	Red, Green, Blue representing a colored image
ROI	Region Of Interest
SDK	Software Development Kit
VVML	Voice and Vision Machine Learning

1. Introduction

The Lattice™ sensAI™ Edge Vision Engine (EVE) tool is a software library that performs edge AI and computer vision on an image to extract data about your presence. EVE utilizes a combination of central processing unit (CPU), graphics processing unit (GPU), and neural processing unit (NPU) to achieve maximum efficiency. EVE focuses on Attention-sensing algorithms, computing your distance from the camera, detecting signs of fatigue, assessing your gaze direction, and more. The data computed by EVE is available to other applications via the EVE software development kit (SDK). EVE Visualizer is a software application that enables you to visualize different components of EVE directly on the camera feed.

2. Hardware Requirements

2.1. Windows 11 PC

A Windows® 11 PC with the following minimum requirements is needed to run EVE:

- CPU:
  - Intel® i5 processor, or better.
  - AMD® Ryzen™ 5 series, or better.
- GPU:
  - Intel Integrated Graphics, with OpenCL™ 2.0 support.
  - AMD Integrated Graphics, with OpenCL 2.0 support.
- Memory:
  - Minimum 8 GB of RAM.
- Storage:
  - Minimum of 1 GB.

2.2. Raspberry Pi 5 Arm

A Raspberry Pi 5 with the following minimum requirements is needed to run EVE:

- CPU:
  - Raspberry Pi 5 (Broadcom® BCM2712 2.4 GHz quad-core 64-bit Arm® Cortex®-A76).
- GPU:
  - Raspberry Pi 5 (VideoCore VII GPU).
- Memory:
  - Minimum 8 GB of RAM.
- Storage:
  - 32 GB microSD card or more extensive.
- Power supply:
  - 5 A USB-C power supply.
- Cooling system:
  - Any active heat sink designed for Raspberry Pi 5.

2.3. Other Hardware Recommendations

2.3.1. Camera Recommendations

Consider the following recommendations when using EVE:

- Recommended RGB webcam for general evaluation: Lenovo® 510 FHD.
- Recommended IR camera for evaluation: To be defined in a future release.

2.3.2. External Display Recommendations for Raspberry Pi

For a better viewing experience, Lattice recommends using a full HD display with HDMI ports. The Raspberry Pi 5 only outputs a display via the two micro-HDMI ports. To avoid using signal converters, Lattice recommends using a micro-HDMI to HDMI cable.

3. Requesting a Product Key

EVE comes with a 30-day evaluation period that requires no product key. When the 30-day evaluation period is over, a product key is required to activate the EVE. This product key may have already been provided to you, where you can skip the trial and activate the EVE using the product key. Otherwise, you can request a product key by providing the following information in an email to *evekey@latticesemi.com*:

- Full name and email address of recipients for a product key.
- Name and contact information of the distributor (or other sales contact) that introduced you to EVE.
- Name of the organization you represent.
- Summary of your intended usage of EVE and/or the problem you want to solve with EVE.

A product key can be provided within 1–2 business days.

4. Software Setup

4.1. Installing EVE on Windows x64

To install EVE in Windows x64, follow these steps:

1. Download the latest revision of the *Lattice-sensAI-EVE-SDK_v6.X_YYY-MM-DD.zip* file from the Lattice sensAI Edge Vision Engine Tool web page.
2. Unzip the package in an empty folder.
3. Open a File Explorer window in the folder that is unzipped.
4. Run *TurboActivate.exe* and enter the product key.

You can now test the EVE by running the EVE Visualizer program. See the Launching EVE Visualizer on Windows x64 section.

4.2. Installing EVE on Raspberry Pi 5 Arm

To install EVE on a Raspberry Pi 5 Arm, follow these steps:

1. Insert the destination microSD card into a computer.
2. Download the Raspberry Pi image (*Lattice-sensAI-RPi-EVE-SDK_v6.X_YYY-MM-DD.img.gz)* from the Lattice sensAI Edge Vision Engine Tool web page.
3. Download and install the Raspberry Pi Imager from the Raspberry Pi web page.
4. Open the Raspberry Pi Imager.
5. Click **CHOOSE OS**, scroll down, and select **Use custom.**

6. Locate and select the file downloaded in step 2.
7. Click **CHOOSE STORAGE** and select the microSD as the destination.
8. Click **NEXT**.
9. Click **NO** on the pop-up window to apply OS customization.
10. Wait for the imaging process to be completed.
11. Remove the microSD card from the computer when a pop-up window from the Raspberry Pi Imager shows the process is complete.
12. Insert the microSD card into Raspberry Pi 5 and turn the power on.
13. Log in using the following credentials:
    a. Username: demo
    b. Password: Drive2Lattice

You can now test EVE by running the EVE Visualizer program. See the Launching EVE Visualizer on Raspberry Pi 5 Arm section.

5. CrossLink-NX-33 VVML Board Integration

EVE acts as a bridge between you and the CrossLink™-NX-33 Voice and Vision Machine Learning (VVML) board. EVE can read the data computed and generated by the CrossLink-NX-33 VVML board, display images and outputs from the board for easier debugging, and forward this information to other applications through the SDK. Furthermore, EVE can perform more computation on the CrossLink-NX-33 VVML board video feed, augmenting the data sent to external applications. Currently, the support for the CrossLink-NX-33 VVML board is only on the Windows platform. Support for Raspberry Pi 5 is planned for a future release.

5.1. CrossLink-NX-33 VVML Board Setup for EVE

To have EVE running alongside a CrossLink-NX-33 VVML board, use the following considerations:

- When the board is connected to the computer, Windows assigns a COM port number to the USB cable. This COM port number must be specified in the EVE Visualizer to ensure that EVE can identify the correct port for connection. You can find this information on Windows Device Manager.
- All options, except for the **draw** options, must be set before starting streaming from the CrossLink-NX-33 VVML board. In the current configuration, the CrossLink-NX-33 VVML board does not support interrupts for back-and-forth communications.

For more information on the CrossLink-NX-33 VVML board setup, refer to the FPGA AI Firmware Pipeline User Guide (FPGA-UG-02229).

6. Features and Applications

6.1. EVE Supported Features

The table below indicates the capabilities supported by different platforms and camera types.

Table 6.1 EVE Supported Features

Feature	Platform			
	Windows x64 with RGB Camera	Raspberry Pi 5 Arm with RGB Camera	Raspberry Pi 5 Arm with IR Camera	CrossLink-NX-33 VVML with Windows x64
3DHP (x, y, z)	Supported	Supported	Supported	Not supported
3DHP (pitch, yaw, roll)	Supported	Supported	Supported	Supported[1]
Face Landmarks	Supported	Supported	Supported	Not supported
Face ID	Supported	Supported	Not supported	Supported[1]
Gaze	Supported	Supported	Supported	Not supported
Fatigue	Supported	Supported	Supported	Not supported
Depth	Supported	Supported	Supported	Supported[1]
Eyewear Detection	Supported	Supported	Not supported	Not supported
Visual Speech Detection	Supported	Supported	Not supported	Not supported
Person Detection	Supported	Supported	Not supported	Supported[1]
Object Detection	Supported	Supported	Not supported	Not supported
ROI Selection	Supported	Not supported	Not supported	Not Supported
Hand Gesture Detection	Not supported	Supported	Not supported	Not supported

Note:

1. Supported via the CrossLink-NX33-VVML Person Detection AI pipeline, also referred as Car Sentry.

Currently, the support for the CrossLink-NX-33 VVML board is only on the Windows platform. Support for Raspberry Pi 5 is planned for a future release.

6.2. EVE Visualizer

EVE Visualizer is a tool used for developing, testing, demonstrating, and evaluating EVE and algorithms. This tool connects to the cameras, feeds images to the engine to process, and receives data to display. The EVE Visualizer also contains elements that turn all engine features on or off. This application includes a camera manager that enables you to choose from various image resolutions and formats. In the EVE Visualizer, features and the corresponding settings are grouped in tabs.

6.2.1. Launching EVE Visualizer on Windows x64

To launch EVE Visualizer on Windows x64, follow these steps:

1. Open a File Explorer window in the unzipped folder from the setup in the Installing EVE on Windows x64 section.
2. Double-click the *EveVisualizer.exe* file.
3. Select a camera and resolution from the top left boxes.
4. Click **Start Streaming**.
5. EVE Visualizer displays the live feed of the selected camera.
6. Toggle on/off algorithms via tabs on the left of the application.

6.2.2. Launching EVE Visualizer on Raspberry Pi 5 Arm

To launch EVE Visualizer on a Raspberry Pi 5 Arm, follow these steps:

1. Open a terminal and move to */usr/local/bin* using this command:
   ```
   cd /usr/local/bin
   ```
2. Launch the EVE Visualizer using this command:
   ```
   ./ EveVisualizer
   ```
3. Select a camera and resolution from the top left boxes.
4. Click **Start Streaming**.
5. EVE Visualizer displays the live feed of the selected camera.
6. Toggle on/off algorithms via tabs on the left of the application

6.2.3. EVE Visualizer Main Window

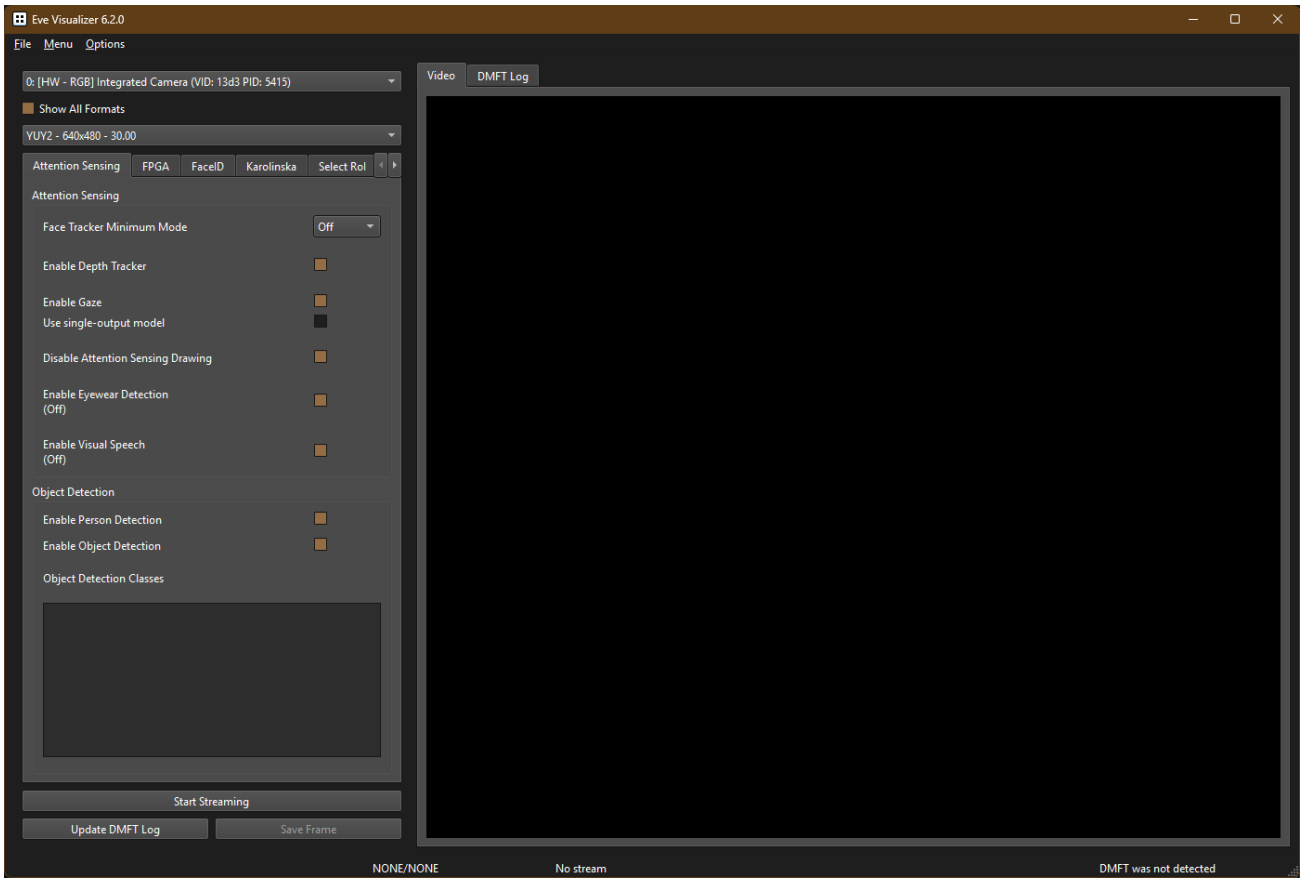

Figure 6.1. EVE Visualizer Main Window

The parameters of the **EVE Visualizer** main window are as follows:

- Camera list dropdown box—Selects a camera. The dropdown box lists all cameras supported by EVE.
- **Show All Formats**—Filters formats and resolutions by default to display only the preferred formats and resolutions. Turning on this option adds formats and resolutions to the format and resolution dropdown box.
- Format and resolution dropdown box—Selects a format and resolution from a preferred list of formats and resolutions. If **Show All Formats** is selected, the list shows all available formats and resolutions for the selected camera.

- Feature tabs—Contains all options for the various algorithms available in the EVE. Each tab is described in the subsequent sections. The tabs are scrollable from left to right, using the arrows on the top right.
- **Video** tab—Displays the video coming out of the EVE algorithm pipeline.
- **DMFT log** tab—This tab will be removed in a future release.
- Start and Stop Streaming
  - **Start Streaming**—Starts the pipeline using an image from the selected camera in the selected format and resolution. Images are displayed in the **Video** tab. Camera, format, and resolution cannot be changed when streaming starts. When streaming starts, this button becomes **Stop Streaming**.
  - **Stop Streaming**—Stops the processing pipeline and camera feed. You can change the camera, format, and resolution.
- **Save Frame**—Saves a single image from the pipeline.
- **Update DMFT log**—This button will be removed in a future update.
- The information at the bottom row is as follows:

Figure 6.2. EVE Visualizer Main Window (Bottom Row)

  - Camera name—Displays the name of the selected camera when streaming starts.
  - Camera format and resolution—Displays the format and resolution from the camera when streaming starts.
  - Pipeline input format/output format—Displays the format from the input of the pipeline, followed by the format and resolution from the output of the pipeline when streaming starts. EVE can transform the format and resolution of the image passing through its pipeline.
  - Timestamp
    - *V*: viewer frame time—Time taken to acquire the image from the camera.
    - *G*: global frame time—Time taken to perform a complete cycle (acquiring the image and computing EVE pipeline).
    - *P*: pipeline frame time—Time taken to compute active algorithms in the EVE pipeline.
    - The color of the text varies based on the value of *P* over the value of *G* (*P/G*):
      Green: *P/G* < 33%
      Yellow: 33% < *P/G* > 66%
      Red: 66% < *P/G*
  - *DMFT was not detected*—This label will be removed in a future release.

6.2.4. FPGA Tab

When using a camera embedded on a CrossLink-NX-33 VVML board, the FPGA tab is the primary tab, with all options available for setting up and connecting to the CrossLink-NX-33 VVML board. Set up options before starting streaming from the CrossLink-NX-33 VVML board. Drawing options can be selected when streaming starts.

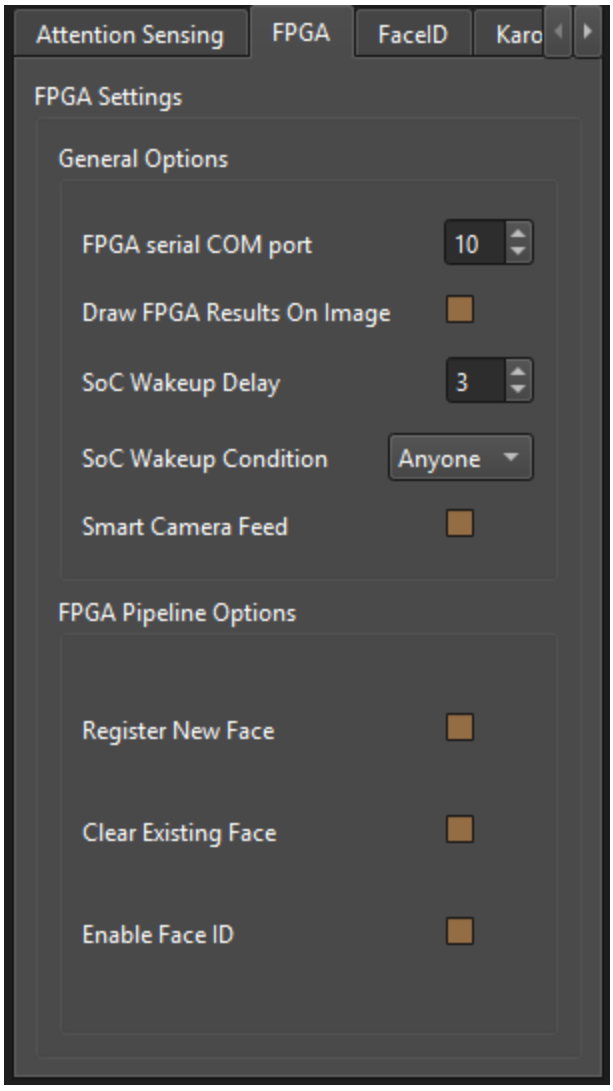

Figure 6.3. EVE Visualizer Main Window (FPGA Tab)

The parameters of the **FPGA** tab are as follows:

- **FPGA serial COM port**—Specifies the serial port number (COM1, COM2, and so on) on Windows, that is used to communicate with the board over UART. If multiple COM ports are available on the system, use the **Device Manager** to identify the port used by the FPGA.

  Note: Failure to use the correct port may result in issues with proper rendering.
- **Draw FPGA Results On Image**—Selects this option to enable rendering of FPGA results on the image. Multiple bounding boxes are drawn. Bounding boxes from person detection is green for you and dark blue for other detected person. Person detection bounding boxes also have a label *CLOSE* or *FAR* based on the distance of the person from the camera. Bounding boxes from face detection is light blue for your face and red for other detected faces.
- **SoC Wakeup Delay**—Specifies the time delay after which the image feed resumes when the wakeup condition is met.
- **SoC Wakeup Condition**—Selects the condition for the Smart Feed feature.
- **Smart Camera Feed**—Selects this option to turn off the image feed when no person is detected.

  Note: Enable this option before streaming starts.

- **Register New Face**—To register a new face, selects this option and the FPGA board is reset and waiting. When the streaming starts, the first face detected is registered.
- **Clear Existing Face**—Registers a new face the same way as the **Register New Face** option, except that this option clears the previously registered face.
- **Enable Face ID**—Selects this option to register or clear a new face. Data from this feature is shown in the Debug window. You can open the Debug window from **Menu > Open Debug Window** or by using the shortcut: Ctrl + D.

Table 6.2 Supported Features by FPGA Pipeline

Pipeline / Options	Car Sentry
Face Bounding Boxes	Supported
Face Landmarks	Not supported
Face Angles	Supported
Face Center	Not supported
Face Confidence	Not supported
Person Bounding Boxes	Supported

6.2.5. Attention Sensing Tab

Attention-sensing features are features related to you and your attention. EVE computes data about your attention. This feature can be used to augment machine interaction by giving added context to the interaction. This feature also computes fatigue data based on you, the depth, and many other factors.

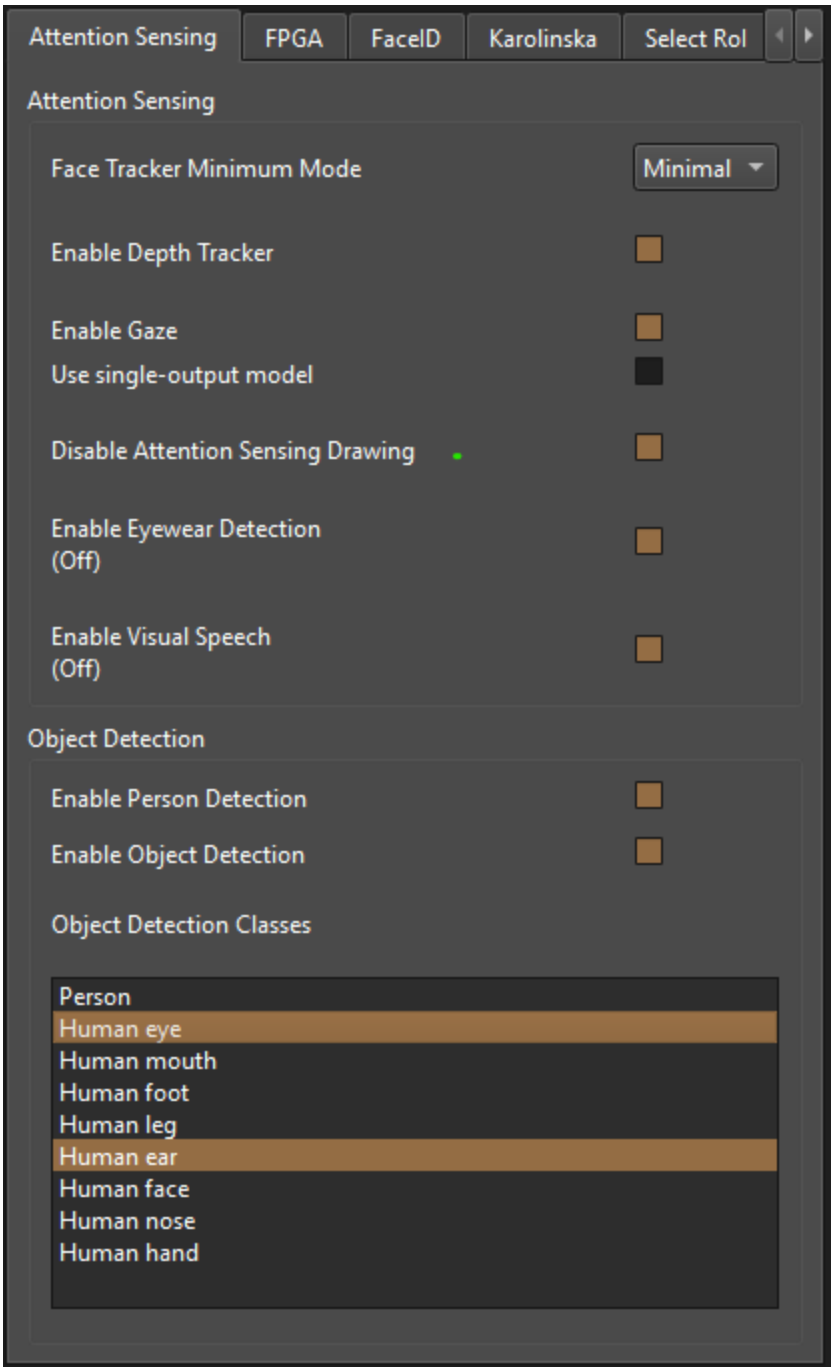

Figure 6.4. EVE Visualizer Main Window (Attention Sensing Tab)

The parameters of the **Attention Sensing** tab are as follows:

- **Face Tracker Minimum Mode**—The EVE pipeline is aware of the algorithms and the corresponding dependencies. Activating a feature automatically turns on the dependencies. EVE face tracker features three modes that compute different levels of data to conserve power. This setting forces a minimum mode for the system.
- **Enable Depth Tracker**—Computes the depth of the tracked person. Displays a scale on the right side of the screen that shows the current position with the minimum and maximum supported ranges.
- **Enable Gaze**—Computes the gaze of the tracked person. This option displays the direction of your gaze with yellow arrows starting from the eye center. Enabling gaze enables eyewear detection implicitly.
- **Use single-output model**—Reserved for future use.

- **Disable Attention Sensing Drawing**—Removes all drawings from the image to avoid attention-sensing features.
- **Enable Eyewear Detection**—Detects whether the tracked person is wearing glasses. Updates the label with the value.
- **Enable Visual Speech**—Detects if the tracked person is speaking, based solely on mouth movement. This option does not involve sound processing.
- **Enable Person Detection**—Detects people from the image. This option draws a green bounding box around the detected person and writes, in purple, the ID of the person and the confidence level of the algorithm, ranging from 0.0 to 1.0.
- **Enable Object Detection**—Detects objects on the screen. Like person detection, this method draws a green bounding box around the detected object and writes, in purple, the name and ID of the object, and the confidence level, ranging from 0.0 to 1.0. Detects mobile phones, bottles, mugs, and notebooks.
- **Object Detection Classes**—Enables the drawing of the classes listed in the box. Clicking the objects listed displays the green bounding boxes on the image, and the name, ID, and confidence level of the object, ranging from 0.0 to 1.0.

6.2.6. FaceID Tab

This feature can identify you against a list of registered users. This list is stored in a gallery file. Calibrating users generates the gallery.

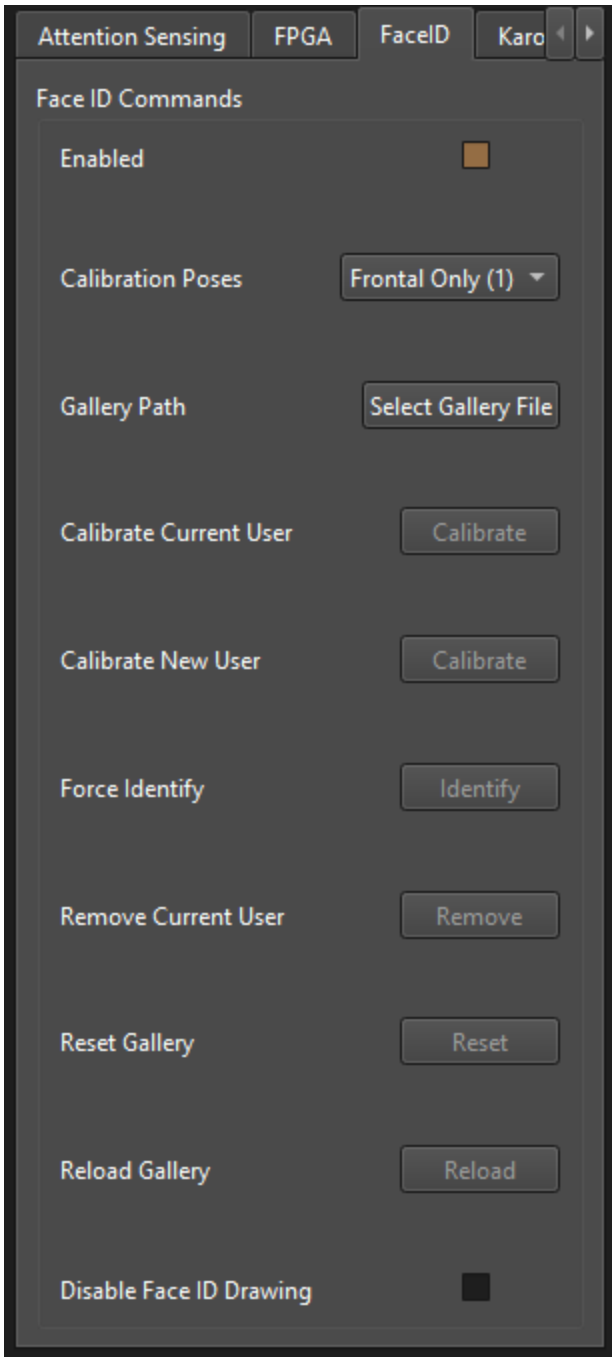

Figure 6.5. EVE Visualizer Main Window (FaceID Tab)

The parameters of the **FaceID** tab are as follows:

- **Enabled**—Starts identifying the tracked person on screen. The text appears above the detected person, depending on the current state of the person. If the person is not identified, a red message shows *ID: Not Verified*. If the person matches an entry in the gallery file, a green message shows *ID: [ID NUMBER]*.
- **Calibration Poses**—The current version of the algorithm only supports one form of calibration, Frontal Only, with a single pose. If multiple forms of calibration are supported, the calibrations are listed in this drop-down list.
- **Gallery Path**—The gallery file contains the list of calibrated users. Allows you to provide a gallery file that is created on another computer running the EVE.

- **Calibrate Current User**—Adds the pose of the current user to the gallery entry. Current users must already have an entry in the gallery file.
- **Calibrate New User**—Creates a new entry in the gallery file for the current user.
- **Force Identify**—Forces the algorithm to perform an identification phase.
- **Remove Current User**—Deletes the current user for the gallery.
- **Reset Gallery**—Deletes every entry from the gallery file.
- **Reload Gallery**—Forces the algorithm to load the gallery file. If this option is used after using the **Gallery Path** option, this option loads in the new gallery file.
- **Disable Face ID Drawing**—Removes the Face ID drawing on the screen while the algorithm continues to run.

6.2.7. Karolinska Tab

The Karolinska Sleepiness Scale is a scale that measures the sleepiness of a tracked user based on various facial fatigue metrics.

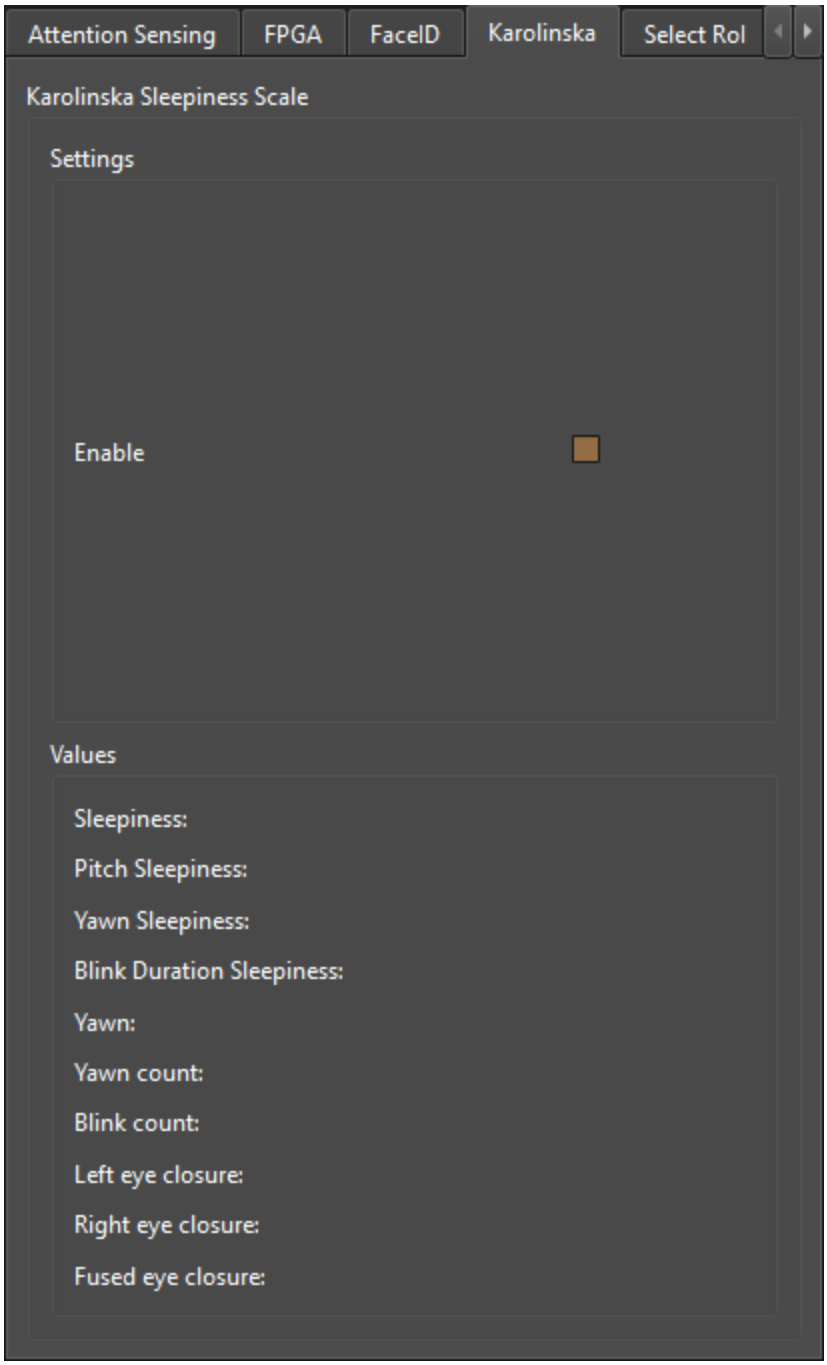

Figure 6.6. EVE Visualizer Main Window (Karolinska Tab)

The parameters of the **Karolinska** tab are as follows:

- **Enable**—Turns on or off the Karolinska sleepiness feature. No additional drawing takes place on screen; instead, the values are displayed in the values panel.
- **Sleepiness**—The final sleepiness score on a scale from 1 (most alert) to 9 (fighting for sleep). This value represents the maximum individual sleepiness score.
- **Pitch Sleepiness**—A sleepiness score based on head pitch angle. If the head pitch falls about 30 degrees below the horizon, the sleepiness value goes up to 8. A second event falling below the threshold sets the sleepiness value to 9.

- **Yawn Sleepiness**—A sleepiness score based on the time between yawn events. The first yawn serves as a starting point for measuring the duration between consecutive yawns. The shorter the interval between yawns, the higher the sleepiness score.
- **Blink Duration Sleepiness**—A sleepiness score based on blink duration. The longer a blink lasts, the higher the sleepiness score.
- **Yawn**—A value between 0 and 1 of the mouth opening. 0 means mouth closed, 1 means a complete yawn. Smiles do not affect this score.
- **Yawn count**—The number of yawns counted since the feature is enabled.
- **Blink count**—The number of blinks of both eyes detected since the feature is enabled.
- **Left eye closure**—A scale from 0 to 1 on how much the left eye is closed. A value of 1 means the left eye is fully closed.
- **Right eye closure**—A scale from 0 to 1 on how much the right eye is closed. A value of 1 means the right eye is fully closed.
- **Fused eye closure**—Takes an average of both eyes, considering the confidence (visibility) of each eye to calculate a fused closure of both eyes.

6.2.8. Select RoI Tab

EVE enables the SDK-client application to create regions of interest (RoI) and sends notifications when your gaze interacts with the regions (that is, entering, being in, or leaving a region of interest). EVE Visualizer represents regions visually by displaying a dark, transparent overlay over the screen, allowing you to dynamically define regions with mouse clicks and display gaze locations on the screen.

This feature is currently available on the Windows x86 platform. Support for the Raspberry Pi platform will be available in future releases.

The parameters of the **Select RoI** tab are as follows:

- **RoI Selection Enable**—Shows the dark transparent overlay when launched. From this point, you can create RoI by left clicking on the transparent background. Click and hold allows you to move the RoI. When your gaze enters the RoI, the region becomes green, transitioning from transparent to solid based on the duration you remain in the RoI. When you leave the RoI, the region turns yellow and gradually fades to transparent, depending on the time spent outside the RoI.
- **RoI Selection Response Time**—The amount of time gaze needs to stay inside the RoI before triggering the entering phase, and the amount of time gaze needs to stay outside the RoI before triggering the leaving phase.

6.2.9. Main Window Menus

6.2.9.1. File

The list in **File** is as follows:

- **Save Frame** (shortcut: Ctrl + S)—Saves a single image from the pipeline.

6.2.9.2. Menu

The list in **Menu** is as follows:

- **Open Debug Window**—Opens a window that allows you to see more data written on the right panel. You can find the Face ID from FPGA computation in this window. Other options are not available.
- **Open Screen and Camera Window** (shortcut: Ctrl + L)—Opens a window that allows you to enter the position of the camera relative to the top-left corner of the screen, in millimeters.

6.2.9.3. Options

The list in **Options** is as follows:

- **Unlimited Pipeline Framerate** (shortcut: Ctrl + U)—This option is not available and does not affect the pipeline running with live feed.
- **Display Framerate in FPS** (shortcut: Ctrl + P)—Changes the framerate display in the main window from a time in milliseconds to a number representing how many frames the EVE is processing per second.

7. EVE SDK Usage

The EVE SDK is a C interface that focuses on the attention-sensing features of the engine. You can control the EVE and decide which features are computed on every frame. EVE SDK also allows you to interact with the CrossLink-NX-33 VVML board. See the CrossLink-NX-33 VVML Board Integration section. You can get the computed data from the CrossLink-NX-33 VVML board through the EVE results.

For more information on the EVE SDK data structures, functions, and code examples, refer to the documentation folder in the package.

7.1. EVE SDK Setup on Windows x64

To communicate with the EVE, an external application must copy the EVE binaries to the bin folder, add the binaries to the project dependencies, and include the EVE header files in the additional include list.

Reference

- FPGA AI Firmware Pipeline User Guide (FPGA-UG-02229)
- CrossLink-NX web page
- CrossLink web page
- Lattice sensAI Solution Stack web page
- Lattice sensAI Edge Vision Engine Tool web page
- Raspberry Pi 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 1.1, April 2025

Section	Change Summary
All	Renamed document from *Lattice sensAI Edge Vision Engine SDK* to *Lattice sensAI Edge Vision Engine Tool*.
Abbreviations in This Document	• Added abbreviations: 3DHP, DMS, IR, and RGB. • Removed abbreviations: AI, IC, OpenCL, and RAM.
Introduction	Updated this section.

Hardware Requirements	• Renamed section *2 Installation* to section 2 Hardware Requirements.
	• Renamed subsection *2.1 Pre-requisite* to section 2.1 Windows 11 PC.
	• Added the following subsections:
	  • 2.2 Raspberry Pi 5 Arm
	  • 2.3 Other Hardware Recommendations

Requesting a Product Key	Added this section.
Software Setup	Reworked subsection *2.2 Installation Steps* and renamed to section 4 Software Setup.
CrossLink-NX-33 VVML Board Integration	• Reworked section *4 CrossLink-NX-33 Integration* and moved to section 5 CrossLink-NX-33 VVML Board Integration. • Reworked subsection *4.1 Setup* and renamed to subsection 5.1 CrossLink-NX-33 VVML Board Setup for EVE.
Features and Applications	• Added this section. • Reworked section *5 CameraViewer* and renamed to subsection 6.2 EVE Visualizer. • Reworked subsection *5.1 FPGA Tab* and moved to subsection 6.2.4 FPGA Tab. • Reworked subsection *5.2 Attention Sensing Features* and moved to subsection 6.2.5 Attention Sensing Tab.
EVE SDK Usage	• Reworked section *3 Usage* and renamed to section 7 EVE SDK Usage. • Reworked subsection *2.3 EVE SDK Setup* and renamed to subsection 7.1 EVE SDK Setup on Windows x64.
References	Updated references.

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Section	Change Summary
All	Initial release.

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