Introduction to VR system in ABL

1 Introduction

This manual is to provide information to work with the virtual reality “VR1” -headset (Varjo) in Aalto Behavioral Laboratory (ABL). More detailed information can be found from Varjo webpages:
https://varjo.com/use-center/getting-started/
https://developer.varjo.com/

Contact ABL personnel in any trouble.

1.1) Equipment

Equipment consists of Varjo devices, controllers, base stations and computers+monitors.

Table 1: The VR system components

Product	Image
Headset (+cable)	 ID: 2AROD=001
Link box	 ID: 2AROD-002

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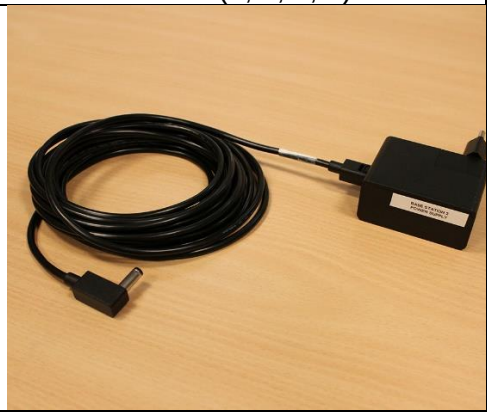
Link box power supply	 Model: S51A00
Base station 4x	 ID: 2AES41004 (1, 2, 3, 4)
Base station power supply 4x	

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Vive Pro Controller 2x	 Model: 2PR7200 ID: NM82PR7200 (not individual) SN: FA91PJ002701
Controller power supply 2x	
Virtual Reality PC	  Dell, Precision 3650 Tower

1.2) Installation in ABL

VR headset is installed in the AC-room of ABL. VR-PC locates just outside the measurement room under the table. The headset cables go through the feedthrough into measurement room, where the headset locates. There are four (4) base stations attached on the wall, which tracks the positions of the headset and controllers. Base stations are calibrated into the room and are powered from the mains.

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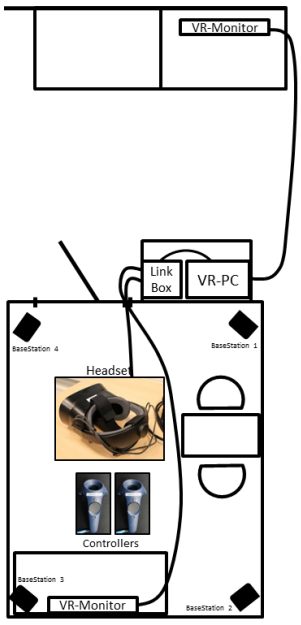

Image 1: VR-setup installation in the AC -room

1.3) System specifications

1.3.1 VR-1 Headset

Bionic Display™	20/20 vision (over 60 PPD / 3000 PPI)
Resolution	2 x 1920x1080 micro-OLEDs (focus) 2 x 1440x1600 AMOLEDs (periphery)
Refresh rate	60/90 Hz
Field of view (FOV)	87°
Weight	605 g (+ headband)
Head tracking	Steam VR Base stations
Eye tracking	
Sampling rate	60/100hz
Accuracy	1°
Precision	0.2°
Monocular / Binocular	Binocular
Works with and without glasses	Both

1.3.2 VR-PC

ABL has dedicated gaming computer for the VR-system. The computer is designed to work with the Varjo-system and fulfills Varjo's requirements perfectly.

Brand	Dell
Model	Precision 3650 Tower
Operating system	Windows 10 Home, 64-bit

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Processor	Intel Core i9-11900K, 16 MB Cache, 8 Core, 3.5 GHz to 5.3 GHz,125W TDP
Graphics	Nvidia GeForce RTX 3090, 24GB, 3DP, HDMI
RAM	32 GB, 2 x 16 GB, DDR4 UDIMM Non-ECC -memory
Hard drive	2TB PCIe NVMe Gen4 Class 40 M.2 SSD

2 Usage

There are ”Get Started” instructions on Varjo’s website (https://varjo.com/use-center/get-started/), about how to get started and to use their system. The whole system, including head tracking, is already installed in the ABL. The main things before using the device are:

1. Open VR-PC and login as VRuser (ask personnel for the admin password)
2. Connect the blue cable (if not already connected) into the link box. This will turn on the headset device. Please remove this cable after the usage, so the headset will turn off.

Image 2: Link box

3. Click VarjoBase icon on the desktop. If everything is connected and remote controllers are powered, then headset, controllers and base stations (4) are visible in the VarjoBase software. Also, the green light will appear on the headset.

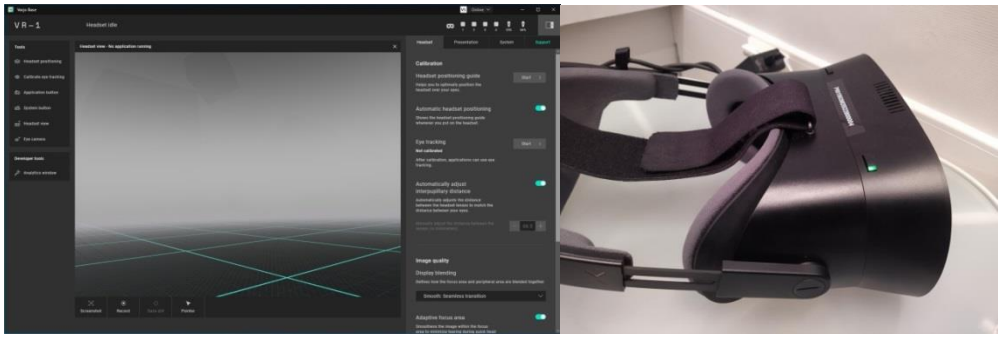

Image 3: Headset, base station and controller icons are shown in the right top corner.

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4. It's recommended to open Analytic window and minimize the main window, before running the experiment. The analytic window enables for example the monitoring of the eye tracking calibration.

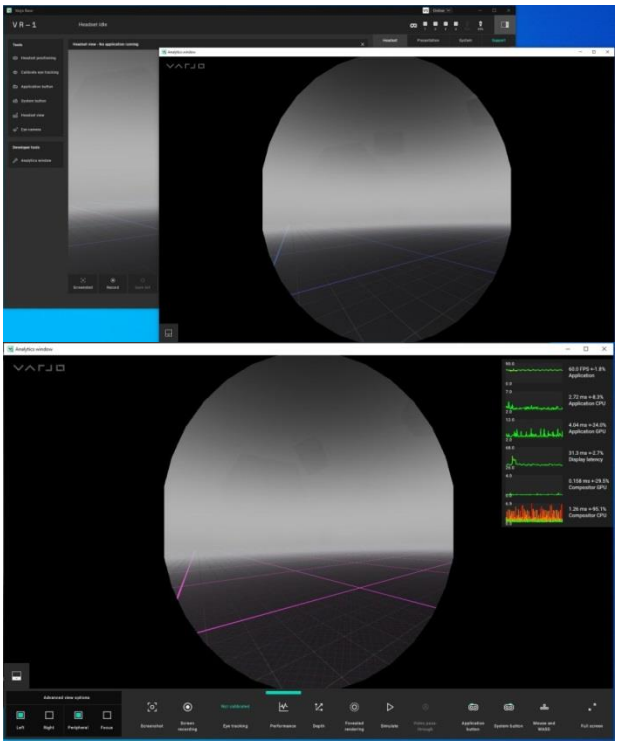

Image 4 Varjo Base analysis window

5. Run your experiment *.exe file.

2.1) Varjo Base

To able to run your experiment, the VarjoBase software needs to be on. When turning on the software, the SteamVR also turns on. SteamVR tracks headset and controllers.

2.2) Steam

Head tracking is implemented with Steam software SteamVR, which controls four (4) SteamVR base stations. SteamVR turns on automatically when using VarjoBase, Unity or Unreal VR-environments.

2.3) Unity

When using Unity, you can use Varjo-XR-plugin to work with the headset. Detailed information on Varjo's website:

Getting Started with Varjo XR Plugin for Unity
https://developer.varjo.com/docs/unity-xr-sdk/getting-started-with-varjo-xr-plugin-for-unity

The main steps are:

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1) When creating a new project, choose Varjo XR compatible pipeline (High Definition Render Pipeline (HDRP) or Universal Render Pipeline (URP)
2) Add Varjo-XR-plugin package from gitURL. Notice that git-support for the Unity needs to installed first on the computer.
3) Project Settings –> Tick the Varjo plugin

4a) Add Track Pose driver to the Main Camera in Unity

4b) Game Object > XR > “Convert Main Camera To XR Rig”

4c) In the Varjo XR-plugin demo, copy the VR-setup for your own project. Delete the original Main camera.

- In the controller demo, copy all controller related objects and scripts.
- In the eye tracking demo, copy all eye tracking related objects and scripts.

2.4) C# code example

This example switches the image of the defined frame in the virtual environment by key press. Image components should be defined in Unity beforehand.

```
{
   public class ImageSwitch : MonoBehaviour
   {
      public Sprite[] spriteList;

      Sprite m_sprite;
      int m_kuva = 0;
      int array_length;
      SerialPort arduino;

      void Start()
      {
         arduino = new SerialPort("COM5", 9600); // Defines the Serial Port
         arduino.Open(); // Opens Serial port

        // Get sprites from the Component define in Unity
         m_sprite = GetComponent<Sprite>();
         m_sprite = this.GetComponent<SpriteRenderer>().sprite;
         array_length = spriteList.Length;
      }

      // This function is update on each refresh of the system
      void Update()
      {
            if (Input.GetKeyDown(KeyCode.RightArrow))
        {
            print("Right button was pressed at " +   Time.timeSinceLevelLoad + " seconds");
            m_kuva = m_kuva + 1;
            if (m_kuva == array_length)
            {
```


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```
            m_kuva = 0;
        }

        this.GetComponent<SpriteRenderer>().sprite = spriteList[m_kuva]; // Changing the sprite
        arduino.Write("1"); //Send code “1” to the serial port
        print("works");
    }
        }
}
```

2.5) Unreal

https://docs.unrealengine.com/4.27/en-US/Resources/Templates/VRTemplate/

3 Demos

Several showcase demos have been downloaded on VR-PC. Most of the files are from Varjo’s website: https://account.varjo.com/downloads. Files are in the C:/ABL_users/Steam/ -folder.

Demo name	Demo type	Engine
Airport Control	Eye Tracker Demo	Unreal
Challenger Bombardier 605	Airplane Cockpit Demo	Unreal
Koyasan Okunoin Cemetery	Photogrammetry Demo	Unity
Nebo Residential Complex	Architecture Demo	Unreal
Trickster VR: Horde Attack!	Steam game	

4 External Devices

VR-1 headset can be used together with external devices. Synchronization is implemented via TTL-triggers. Serial port of VR-PC is connected currently to remote EMG/ECG device, but can be connected to any measuring device in ABL.

4.1) Using serial port

You can write numbers between 1-255 to COM-port. Example of the C#-code in Unity:

```
using System.IO.Ports;

arduino = new SerialPort("COM5", 9600); //Defines the port. You should check the correct port
arduino.Open(); //Opens the port, now it’s ready for use

arduino.Write("1"); //sends a pulse to pin 1
```


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4.2) Using parallel port

Define the output port as following:

```
using System;
using System.Collections.Generic;
using System.Text;
using System;
using System.Runtime.InteropServices;

namespace ParallelPortControl
{
    class PortControl
    {
        [DllImport("inpout32.dll", EntryPoint = "Out32")]
        public static extern void Output(int adress, int value); // decimal
    }
}
```

Notice that inpout32.dll file should in the same folder as you project (may work without).

Then you can use your port as following:

```
ParallelPortControl.PortControl.Output(888, 1); // turns on the pin 1
ParallelPortControl.PortControl.Output(888, 0); // resets the pin (have some delay in the between)
```

5 Eye Tracking

VR-1 headset includes binocular 100Hz eye tracker. You can both collect the eye tracking data for the further analysis and use the gaze information as an interaction tool in your application.

https://developer.varjo.com/docs/get-started/eye-tracking-with-varjo-headset

5.1) Using Varjo Eye Tracking-setup

When using Varjo eye tracking setup, include the Eye Tracking scripts to your VR-setup.Then, when running your script, press “tab” key to record your eye tracking data on CSV-file.

In the Varjo demos, the sampling frequency of the data is 100Hz. For some reasons, the same sampling rate cannot be achieved with other data and the sampling rate with user defined data is 60Hz. So, if you create your own script and add some data on the file, the original data is at 100Hz, but the added data only at 60Hz. This issue has been discussed with Varjo, but currently there is no solution.

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5.2) Running a demo

“Allow eye tracking” in the Varjo Base software, to enable eye tracking.

5.3) Calibration

Eye tracking calibration is required before gaze can be tracked. Calibration can be done in Varjo Base or inside the application (where eye tracking is included). Notice that eye tracker must be recalibrated every time the headset is put on.

To calibrate the eye tracker in Unity, press “space”.

6 Eye Glasses

VR-1 one headset works also with the eye glasses.

7 Controllers

There are two Vive Pro Controllers in the ABL, which can be used in VR experiments. In the VR setup, copy all controller related objects and scripts.

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