XELA ROBOTICS

Software Manual

XELA Sensor Server
Linux and Windows
v1.7.7

Table of contents

General Limitations of the Software

- The software is constantly developing and, therefore, is provided AS IS.
- The code is compiled and tested on 1 PC with Virtual Machines and might have limitations related to different hardware and software configurations.
- There might be code-breaking changes between the releases. You might need to adjust your code or settings to make your software work again. Please check the change log for details and test from a temporary directory before installing the new version!

Important notes

- Some new Linux kernels have streamlined the CAN management, and therefore, serialCAN and PEAK devices can be pulled up with standard socketcan commands as shown with esd devices in this manual.
- Before reporting bugs, please check the XELA support page to see if an update has already been released; if not, follow the checklist on the last page of this manual. Reports not following the checklist can take longer to investigate and fix.
- During the investigation of an issue, if we don’t hear back for 14 days after our side recommendation or fix, we assume the issue is resolved and close the ticket.

Installation

You can unpack Windows and Linux executables to the directory of your liking.

Note: The default xServ.ini file is set up for simulation.
Before making a new configuration, the compatibility of the apps on your system can be tested by running `./xela_server -f xServ.ini` and `./xela_viz -f xServ.ini`.

AppImage executables

Since the release of 1.7.7, the binaries are provided as AppImages for Linux. Those are compiled on an Ubuntu 22.04 virtual machine with settings compatible with both Wayland and Xorg. Users are encouraged to install the AppImage files into the /home/user/.local/bin directory and make them executable there. To simplify the use, AppImage files are renamed to the same binary names as the native apps, and they will work across different OS versions.

Upgrade

Before replacing Windows or Linux executables, try running them from a temporary directory to check the compatibility of the system's apps (See Installation for more details).

Major changes

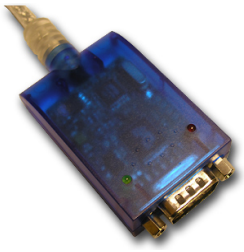
1.7.7 (build 161703)	Major fixes and optimisations Improved temperature compensation
1.7.7 (build 154902)	Fix temperature compensation for calibrated sensors
1.7.7a (build 151312)	Add support for software-managed temperature compensation Add support for the update rate of the sensor Add AppImage release to simplify the full compiling process
1.7.6 (build 137302)	Fix the issue with calibrated data not working on some sensors Add support for calibrated 4x6 sensors
1.7.6rc (build 133105) Release Candidate	Fully calibrated sensor support Optional sensor modules New model names Upgrade to Python 3.11 on Linux (and Python 3.10 on Windows)
1.7.5 (build 96513)	Added support for Ubuntu 22.04 Upgraded Python version in Windows to 3.9 with new custom ntcan library for Windows and Ubuntu 20.04 and 22.04 Bug fixes
1.7.4 (build 66608)	Fixed an issue of delays on some PCs Added detection of Version 3 controllers if used as earlier one The configuration tool will be able to determine version 3 controllers
1.7.3 (build 64309)	Fixed issues with XR1946 sensors Added allowance for grammar mistakes in the INI file Optimised the INI parser

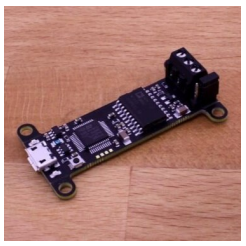
Warning
Version 1.7.x will require setting ctr_ver = 3 on some newer sensors
Version 1.7.0 can use sensor arrays through .xela files - separating sensors will not be possible when using an array

Using the Server

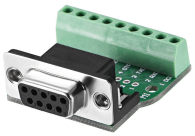
Compatible CAN converters

Note: The following list includes only devices we have tested on. Other devices might also work.

Converter	Compatibility	Pros	Cons
 Esd CAN-USB/2 Esd CAN-USB/3	Windows (esd) Linux (socketcan)	Sturdy design High-speed	It works very differently in Windows and requires special drivers Reliable in Linux, but a bit slower in Windows Suitable for multi-sensor environments esd CAN-USB/3 FD supported in Windows and Linux (kernel 6.6 or newer)
 PEAK USB-CAN (PCAN)	Windows (pcan) Linux (pcan/socketcan) *Limited support due to the structure of pcan drivers	Cheap Small size	Requires special drivers for all OSs Note: Windows has limited functionality, no automatic module reset Note: It can be challenging to set up in Linux with UEFI and Secure Boot
 LAWICEL CANUSB	Linux (socketcan)	Cheap Small size	It does not work on Windows It uses Serial-over-USB communication, which is slower than the standard CAN bus. Suitable for single-sensor environments
 VScom USB-CAN Plus	Linux (socketcan) Windows (slcan) Raspberry Pi 4 (socketcan)	Mountable Sturdy design	It is not functional on Windows (only for quick tests) It uses Serial-over-USB communication, which is slower than the standard CAN bus. Suitable for multi-sensor environments

Converter	Compatibility	Pros	Cons
 CANable (Pro)	Linux (socketcan)	Small size Micro-USB	No DB9 connector Needs “candlelight” firmware for Linux Suitable for multi-sensor environments
 2-Channel CAN-BUS(FD) Shield for Raspberry Pi	Raspberry Pi 4 (socketcan)	Has 2x CAN bus	Requires compilation of kernel drivers No DB9 connector
 Waveshare RS485 CAN HAT	Raspberry Pi 4 (socketcan)	Has RS485 and CAN bus	No DB9 connector

If using a CAN converter without a DB9 connector, you can buy a DB9 breakout board online.



Connect the cables between the converter and DB9 breakout board as follows:

```
CAN_H → Pin 7
CAN_L → Pin 2
GND   → Pin 3 (highly recommended)
```

Warning

Even though other CAN devices might work, misconnection can break the sensor.

Please always use CAN devices with the standardised DB-9 connector.

OS compatibility

- Windows 8 or later (64-bit with Visual C++ redistributable 2015-2019 x64 installed)
- Ubuntu 18.04, 20.04 and 22.04 (64-bit)
  Other 64-bit Linux flavours, i.e. Debian with kernel 5.13 or newer
- Raspberry Pi OS 10 (32-bit) - server only, no extra tools, Raspberry Pi 4 minimum

Prerequisites

For connecting to XELA Server with user-made Python script, the following Python packages would need to be installed:

- websocket-client

For other languages, compatible libraries would be required.

Warning
Please remember to give sensors sufficient power. An external USB power supply is recommended.
There are 2 USB cables for sensors. Both MUST be connected
Visualisation can be very CPU-heavy; please use a good PC with a dedicated GPU or powerful CPU (i7+/Ryzen 7+) to run it, or consider visualisation on another computer.

Set up

Additional First Steps for Linux

Activating CAN bus

Linux only (Windows requires only drivers. Windows users can skip this part)

If you haven't activated CAN bus yet, please run the following commands:
Note: Make sure you have can-utils installed first

- **Esd or any other CAN device (includes serialCAN and PEAK with the newer kernel)**:
  user@localhost:~$ sudo ip link set up can0 type can bitrate 1000000
  Explanation: First, we will set up the CAN network on can0 with a bitrate of 1Mbit/s, and then we pull it up
- **Any serial CAN (slcan) device**:
  user@localhost:~$ sudo slcand -o -s8 -t hw -S 3000000 /dev/ttyUSB0
  user@localhost:~$ sudo ifconfig slcan0 up
  Explanation: First, we set up a SLCAN device running on /dev/ttyUSB0 with a hardware bitrate of 3Mbit/s and CAN speed of 1Mbit/s (-s8), then we will pull it up

NOTE: Replace can0/slcan0 with the corresponding CAN bus name and ttyUSB0 with the correct device name
NOTE: On some Ubuntu 22.04 installations, the slcand has been upgraded, and it will identify the network as can0 instead of slcan0 so that you can use the same commands as for ESD

Automating activation

Linux only

Note: The following examples might not work with your configuration; only use the instructions as a reference.
You can download our pre-made scripts from github.com/mcsix/can-device-rules

Esd CAN-USB/2 and general CAN devices or serialCAN and PEAK devices under newer kernels

Step 1.
Open/make new network configuration
`sudo nano /etc/systemd/network/80-can.network`

Step 2.
Enter the following into the file

```
[Match]
Name=can*

[CAN]
BitRate=1M
RestartSec=100ms
```

Step 3.
Restart network manager
`sudo systemctl restart systemd-networkd`

VScom USB-CAN Plus and most Serial CAN devices

NOTE: Updated as udev rules have changed over time

Step 1.

Make a new udev rule for your device type (slcan in this example) with

`sudo nano /etc/udev/rules.d/90-slcan.rules`

The use of a higher rule number is recommended in case of errors

Add the following content (note: ensure the command is a single line when you copy-paste):

```
#slcan autoloader

SUBSYSTEM=="tty", ATTRS{idVendor}=="1d6b", ATTRS{idProduct}=="0002",
SYMLINK+="ttyUSB%n", GROUP="dialout", MODE="0777", TAG+="systemd",
ENV{SYSTEMD_WANTS}="slcan@%n.service"
```

Step 2.
Set up service:
`sudo nano /etc/systemd/system/slcan@.service`

```
[Unit]
Description=slcan interface
After=dev-ttyUSB%i.device
BindsTo=dev-ttyUSB%i.device

[Service]
ExecStart=/usr/local/bin/slcan_add.sh %I
Type=forking
```

Step 3.
Make the script to run activation:
`sudo nano /usr/local/bin/slcan_add.sh`

```
#!/bin/sh

sleep 1
slcand -o -c -f -s8 -t hw -S 3000000 /dev/ttyUSB$1 slcan$1
sleep 1
ifconfig slcan$1 up
```

NOTE: On some upgraded machines, the CAN bus identifies as can0 instead of slcan0

Step 4.
Make both scripts executable with
`sudo chmod +x /usr/local/bin/slcan_add.sh`

Step 5.
Reload rules with
`sudo udevadm control --reload-rules`

Step 6.
Reload the systemd config with
`sudo systemctl daemon-reload`

Step 7.
Test and adjust whenever needed

Installing drivers

Windows

Please install the drivers for your CAN-USB converter by downloading them from the manufacturer's website.

Linux

Depending on the distribution and kernel version, there might be a need for PCAN drivers when using PEAK CAN-USB devices. It might also be necessary to build them with DKMS. To do that, run `sudo make -C driver dkms_install` before `sudo make install`.
Please download them from https://www.peak-system.com/fileadmin/media/linux/index.htm.
You might need to sign the kernel modules if your system uses Secure Boot. A good article about this is available at https://superuser.com/questions/1438279/how-to-sign-a-kernel-module-ubuntu-18-04.
Instead of `vboxdrv`, you have to use `pcan`.
PCAN will also require the PCANBasic API to be installed on your system.

Application Installation

Windows

Unpack the downloaded files to your preferred folder
Keep all configuration files in the same folder.
Important: Make sure you have Visual C++ redistributable 2015-2019 x64 installed from https://aka.ms/vs/16/release/vc_redist.x64.exe

Linux

Unpack the downloaded zip file to your preferred directory (we would recommend adding that directory to PATH, especially if you plan to use ROS)
Make /etc/xela directory and give it 777 permissions (can be done with the xela_conf application as well)
Keep all configuration files in /etc/xela directory.

Getting ready

1. Make sure all cables are connected. For CAN devices, there are 2 USB cables, and both MUST be connected, as the one on the sensor side of the CAN-USB converter is for power.
2. Unpack the files to a suitable location.
   In the case of the ROS package, to your catkin workspace folder
3. Open your terminal window (PowerShell or Command Prompt on Windows) and navigate to the correct directory where the files are
4. Run the configuration (first use or when the configuration has changed) or make it manually
   NOTE: If XELA Robotics made you a configuration file, please honour that over this application
   NOTE: If using calibrated sensors, you must use the serial number there instead. You may still use it, but a manual change in the xServ.ini file will be required.
   NOTE: Only to be used with standard **4x4** and **4x6** sensors; otherwise, please make a configuration file manually or consult with XELA Robotics
   NOTE: If using a CAN adaptor other than the esd CAN-USB/2 or is not added to the kernel in Linux, you will need to specify it with the -c flag (i.e. `./xela_conf -c slcan0`)
   Windows PowerShell: ./xela_conf.exe
   Windows cmd: xela_conf.exe
   Linux: ./xela_conf

5. Run the server (mandatory)
   The server will send the data via Websockets. See the arguments section to see all configuration options.
   Windows PowerShell: ./xela_server.exe
   Windows cmd: xela_server.exe
   Linux: ./xela_server

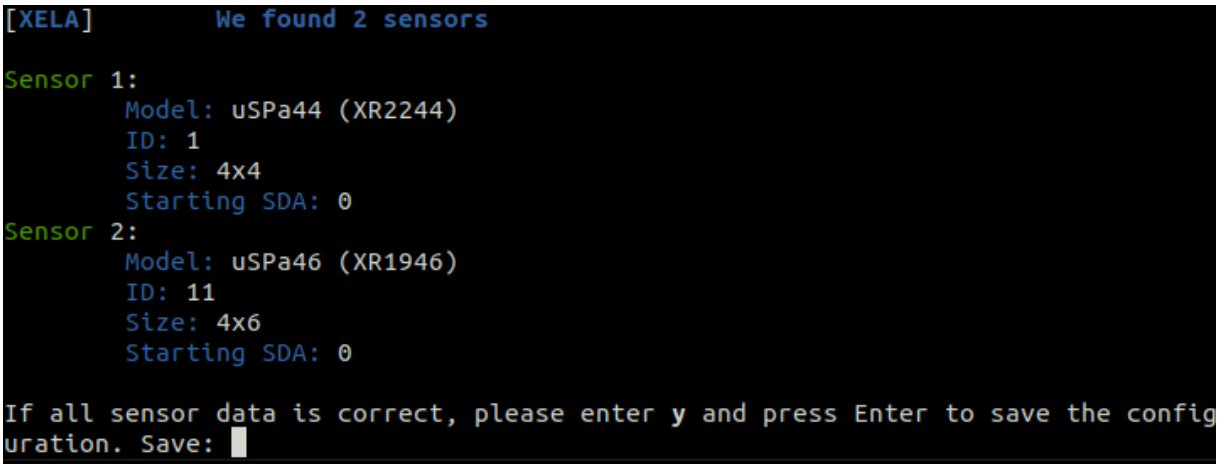
6. Run additional tools
   • Visualizer for showing the sensor status on the screen as dots (size and location based on data)
   Windows PowerShell: ./xela_viz.exe
   Windows cmd: xela_viz.exe
   Linux: ./xela_viz

   • Logger to log sensor data in raw format with UNIX timestamps into the LOG folder as CSV files (all sensors will have a separate filename in the format “sens-[sensor number].csv”. Please see the arguments section to see more detailed information about using it
   Windows PowerShell: ./xela_log.exe
   Windows cmd: xela_log.exe
   Linux: ./xela_log

Application specifics

XELA Configurator

xela_conf



XELA Configurator (Sensor AutoConfig) is a tool that sets up the xServ.ini automatically.
It expects the esd CAN-USB/2 device to be used if no arguments are given. When executing, the user must specify the device type and channel in the terminal for all other devices or if the bus (can0 in Linux) or net ID (0 in Windows) are different.
NOTE: Only for uSPa 44 and uSPa 46 sensors

Windows examples:

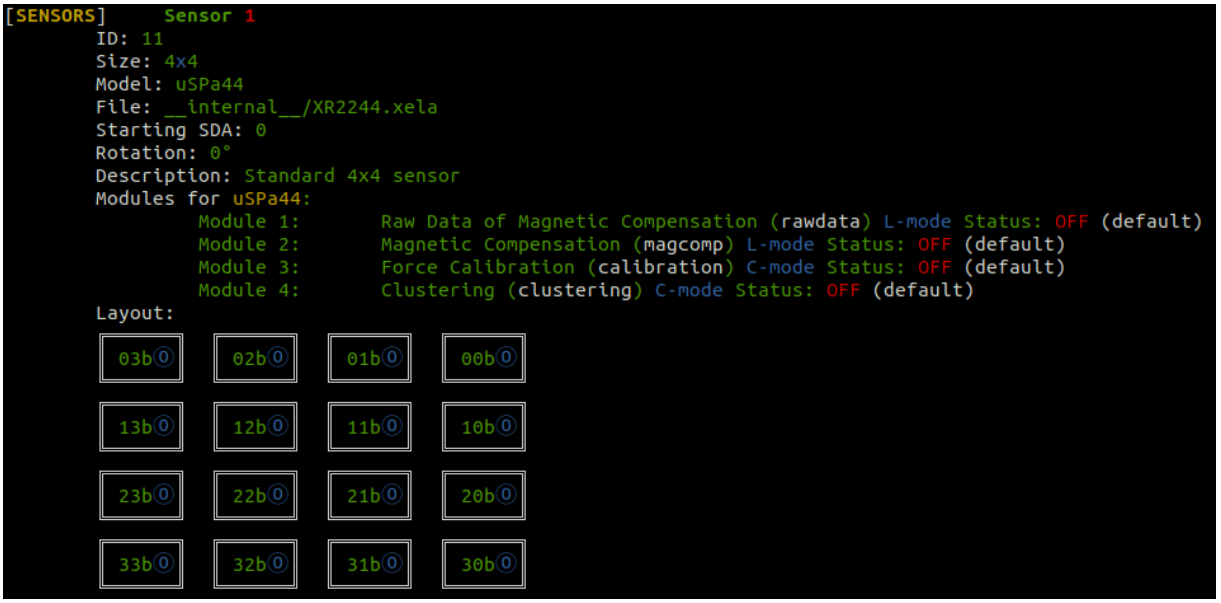
./XELA_Conf.exe -d esd -c 0	Default, esd CAN-USB/2 device on Net ID 0
./XELA_Conf.exe -d slcan -c COM3	VScom or other serial-can devices that show up on COM3 Note: Serial connection can be buggy
./XELA_Conf.exe -d pcan -c PCAN_USBBUS1	PEAK CAN-USB devices, bus/channel names can differ

Linux examples:

./xela_conf -d socketcan -c can0	Default, esd CAN-USB/2 device on can0
./xela_conf -d socketcan -c slcan0	VScom or other serial-can devices that are set up on slcan0
./xela_conf -d pcan -c PCAN_USBBUS1	PEAK CAN-USB devices, bus/channel names can differ

XELA Server

xela_server

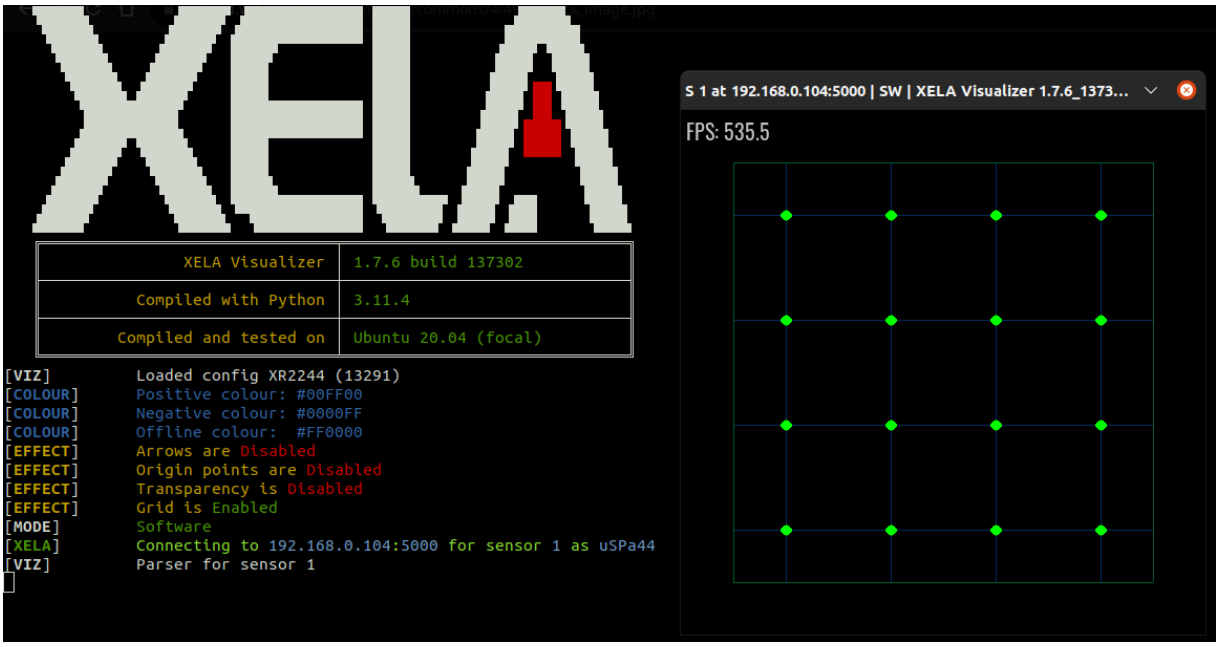


XELA Server is the main tool connecting the sensors to other software.
It will require an xServ.ini file to be present or an alternative specified with arguments.
Some of the essential arguments:

-f filename	To specify the alternative for xServ.ini
--ip xxx.xxx.xxx.xxx	To specify the device IP in case the device has several network devices installed
--port x	To specify a port other than 5000 enables the use of several server apps on the same computer.

XELA Visualisation

xela_viz

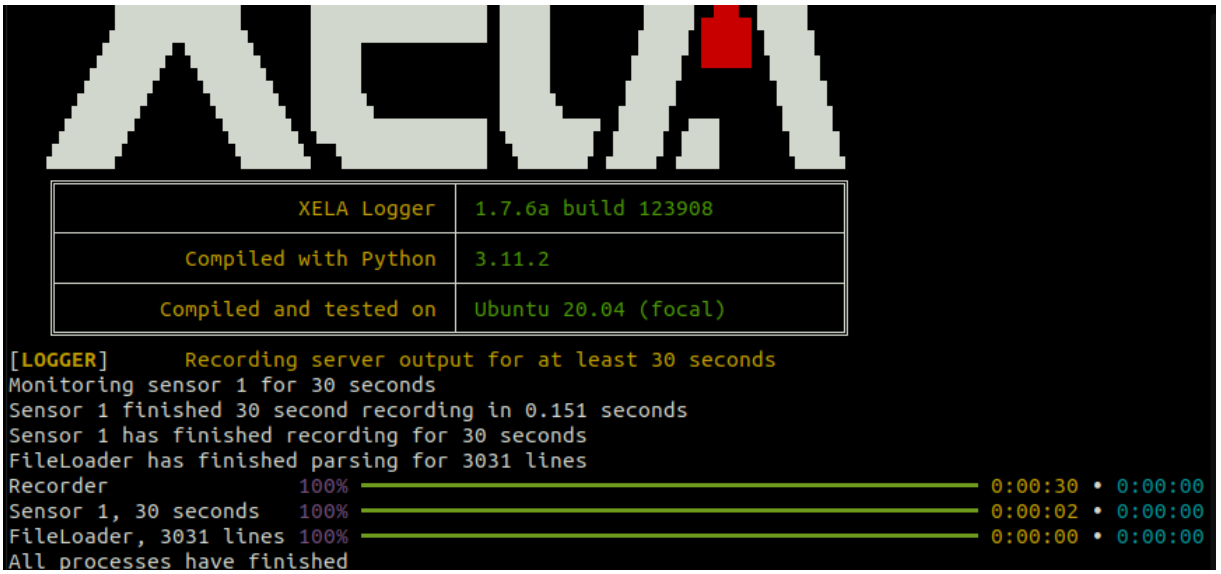


XELA Visualisation is the tool used to visualise the sensor's activity.
It requires both the Server to be running and the xServ.ini to exist.
Some important arguments:

-f filename	To specify the alternative for xServ.ini
--ip xxx.xxx.xxx.xxx	To specify the IP of the server if the computer has several network devices or the Server is running on a different computer
--port x	To specify the port of the Server or middleware if not 5000
--viz x	To specify the sensor to visualise when more than one is available on the Server, and you are not trying to visualise the first one.

XELA Logger

xela_log



XELA Logger is the tool for logging sensor readings into the CSV files.
It requires a detailed argument to know which sensors to read and how long. Details are available under Using -> How to use XELA Logger.
Some of the arguments:

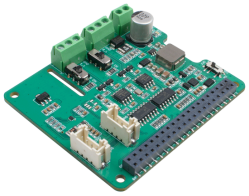
--ip xxx.xxx.xxx.xxx	To specify the IP of the server if the computer has several network devices or the Server is running on a different computer
--port x	To specify the port of the Server or middle-ware if not 5000
-s config	Config for the data to be recorded

Note: Since version 1.7.6, XELA Logger logs all messages into a text file and later parses it to create the CSV files; therefore, accessing the data during the recording process is not possible.

Raspberry Pi

Note: Will work only on Raspberry Pi 4B and is tested on 4 Gb RAM version running Raspian 10 (Raspberry Pi OS)
Note: Will only have major releases and, therefore, might be a few versions behind the main applications

Compatible HATs

	Seeed Studio 2-Channel CAN-BUS(FD) Shield for Raspberry Pi Pro: 2 CAN channels
	WaveShare RS485 CAN HAT

Application Installation

Applications can be installed in any suitable directory. The /etc/xela directory should have 777 permissions, and your xServ.ini file should be placed there.

Limitations of the Raspberry Pi version

The Raspberry Pi version only has the server module and will require another computer to be present for visualisation and logging. There is currently no automatic configuration tool either. The Raspberry Pi will not follow the same release schedule as the software for Ubuntu and Windows.

Using

Arguments

Following is the list of primary arguments that can be given to the executables:
green – used, red – not used
In Windows, it might need .exe at the end of the executable name.

-h Show all argument options for the script with a short description
Usage: [xela_conf, xela_log, xela_server, xela_viz]
Example: ./xela_server -h

-f *filename* The name of the configuration file (with .ini extension) to be used (full path or just name if in the same folder) (default: */etc/xela/xServ.ini* (Linux) or *xServ.ini* (Windows)
Usage: [xela_conf, xela_log, xela_server, xela_viz]
Example: ./xela_server -f myconf.ini

--ip *ip* The IP address for the computer running the server (defaults to the first IP assigned to the computer)
Usage: [xela_conf, xela_log, xela_server, xela_viz]
Example: ./xela_viz --ip 192.168.0.107

-p *port* The port for communicating with the server (default: *5000*)
Usage: [xela_conf, xela_log, xela_server, xela_viz]
Example: ./xela_viz -p 5007

--viz *sensor_number* The sensor number to display in visualisation (defaults to 1)
Usage: [xela_conf, xela_log, xela_server, xela_viz]
Example: ./xela_viz --viz 3

-s *sensor_config* The string for configuring the logging script (default: *1:100*)
More info in How to use XELA Logger
Usage: [xela_conf, xela_log, xela_server, xela_viz]
Example: ./xela_log -s 1-3:1000

-lf *path_to_log_folder* Folder, where CSV files will be saved (default: *CSV/* in Windows or */etc/xela/CSV/* in Linux)
More info in How to use XELA Logger
Usage: [xela_conf, xela_log, xela_server, xela_viz]
Example: ./xela_log -lf MyLogs

--log *log_file* The path to log file (default: */etc/xela/LOG/app.log* in Linux or *LOG/app.log i*n Windows where app corresponds to app name)
Usage: [xela_conf, xela_log, xela_server, xela_viz]
Example: ./xela_server --log my_server_log.log

-d *device* The can device name (default: *socketcan* in Linux or *esd* in Windows)
Usage: [xela_conf, xela_log, xela_server, xela_viz]
Example: ./xela_conf -d pcan

-c *channel* The can device channel (default: *can0* in Linux or *0* in Windows)
Usage: [xela_conf, xela_log, xela_server, xela_viz]
Example: ./xela_conf -c PCAN_USBBUS1

How to use XELA Logger

Entries must be using one of the following formats:

Data	Meaning
1	Sensor* 1 will be read (default 100 broadcast cycles*)
1,2,3	Sensors 1, 2 and 3 will be read (default: 100 broadcast cycles)
1-3	Sensors 1,2 and 3 will be read (default: 100 broadcast cycles) (shortcut)
1:150	Sensor 1 will be read 150 broadcast cycles
1:150,2	Sensor 1 will be read 150 broadcast cycles, and sensor 2 for default 100
1-3:150	Sensors 1, 2 and 3 will all be read for 150 broadcast cycles
1-5,2:150	Sensor 2 will be read 150 broadcast cycles, and sensors 1, 3, 4 and 5 for default 100
1:60t	Sensor 1 will be read for 60 seconds
1-3:30t	Sensors 1, 2 and 3 will all be read for 30 seconds
1-5,2:30t	Sensor 2 will be read for 30 seconds, and sensors 1, 3, 4 and 5 for default 100 broadcast cycles
1-5:200,3:30t	Sensor 3 will be read for 30 seconds, and sensors 1, 2, 3 and 5 will all be read for 200 broadcast cycles.

Example:

	A	B	C	D	E	F	G
1	time	1X	1Y	1Z	2X	2Y	2Z
2	1587029110.17588	16858	18758	35645	15128	15545	31502
3	1587029110.17615	16858	18758	35645	15128	15545	31502
4	1587029110.27562	19188	16018	35189	17276	15273	32799
5	1587029110.2757	19188	16018	35189	17276	15273	32799
6	1587029110.37499	13737	14693	34553	18699	16100	32949
7	1587029110.37511	13737	14693	34553	18699	16100	32949

Note

*When defining an argument for the -s flag, ensure that there are NO spaces in it (after a comma or a colon)
*If the sensor is defined multiple times, the latest entry counts
*Sensors can be from 1 to 64 (to 16 before 1.7.1)
*Time is recorded as a **Unix timestamp** (on all OSs).
The **Unix epoch** (or **Unix time** or **POSIX time** or **Unix timestamp**) is the number of seconds that have elapsed since January 1, 1970 (midnight UTC/GMT), not counting leap seconds (in ISO 8601: 1970-01-01T00:00:00Z). The epoch is Unix time 0 (midnight 1/1/1970), but 'epoch' is often used as a synonym for Unix time. Some systems store epoch dates as a signed 32-bit integer, which might cause problems on January 19, 2038 (known as the Year 2038 problem or Y2038).
*Broadcast cycles depend on the computer configuration and are defined as periodic update cycle

Configuration file format

If your INI needs a custom format, follow these specifics.
Sections in the config file:
[CAN] – defines settings for CAN bus (will be in [server] from 1.8.0 onwards)
[server] – defines settings for the server
[viz] – defines settings for the visualisation
[sensor] – defines primary sensor settings and the number of total boards
[sensor*N*] – (*N* is an integer at least 1, sequential) – defines Nth sensors settings; if different from defaults, you can define *[sensor1]* if it will be different from default settings
Alternative names for the element are in grey.

Section/element	notes/description
[CAN]	Note: Will be deprecated, and all elements will be moved to [server] in 1.8.0
bustype = socketcan busmode type	Bus types based on the driver: Linux: **socketcan**, **pcan** Windows: **esd**, **pcan**, **slcan** Testing: **sim**
channel = can0 can	Channel used for CAN communication, examples: pcan: **PCAN_USBBUS1** esd: **0** socketcan: **can0** / **slcan0** With multi-CAN, the channels must be separated by commas (no spaces). I.e. *channel = can0,can1*

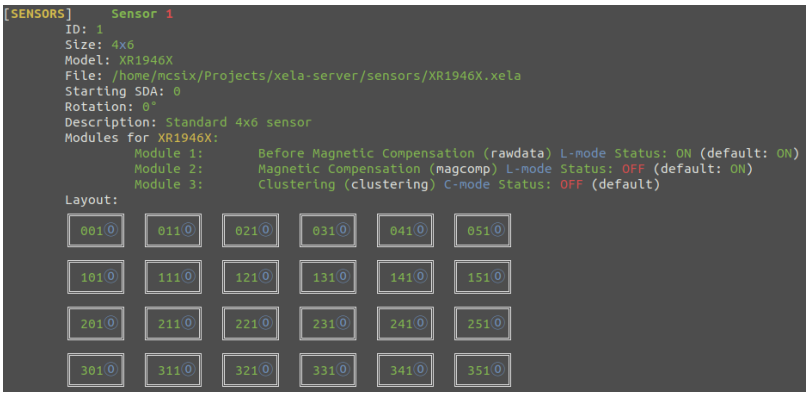
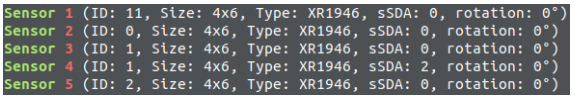
Format details continue on the next page.

Format details continued

Section/element	notes/description
[server]	Bustype and channel are supported here since 1.7.6; they will overwrite details given in [CAN]
bustype = socketcan busmode type	Bus types based on the driver: Linux: **socketcan**, **pcan** Windows: **esd**, **pcan**, **slcan** Testing: **sim**
broadcast = websocket	Broadcast defines the connection method It will have an effect from 1.8.0 onwards. WebSocket is the supported one in 1.7.x
refreshrate = 100	Set periodic send rate per second for the server The default is up to 100 Hz, but it can be limited. Must be an integer between 1 and 1000 (do not go over 100 unless you have a monster computer as it can cause delays and errors)
mode = 0	*(experimental)* Broadcast mode: **0** - periodic only *(default)* **1** - periodic and on CAN message receive **2** - on CAN message receive only **Note:** modes 1 and 2 can be very taxing on your network and CPU
single = on	*(experimental)* Defines if the “on CAN message receive” broadcast contains only taxel update info or the entire message. Modes **1** and **2** only **on** - message will only include sensor number, taxel number and new data (X, Y and Z) **off** - server will generate an entire message of all sensors and taxels like with the periodic message

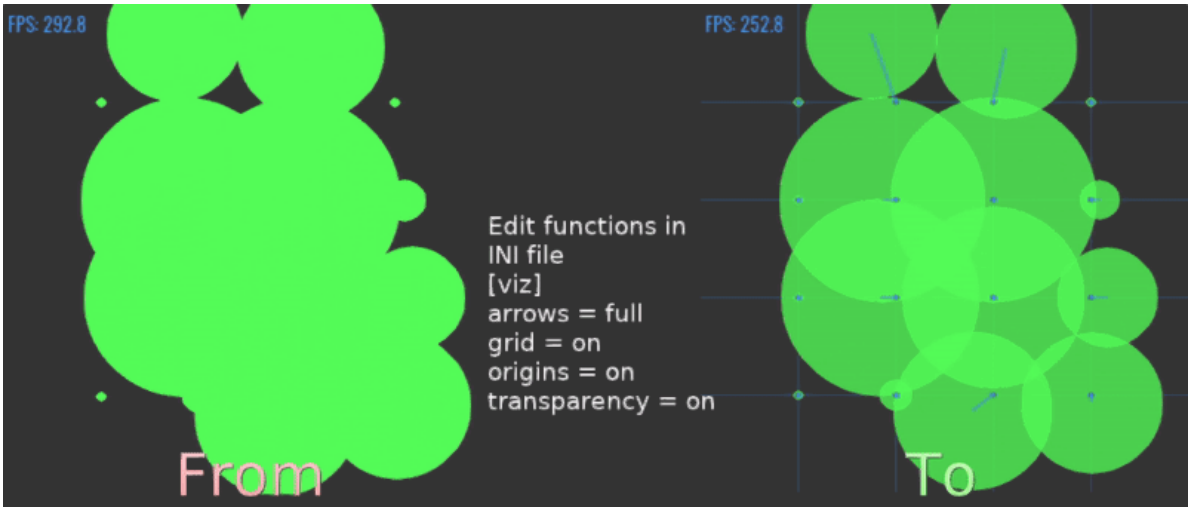
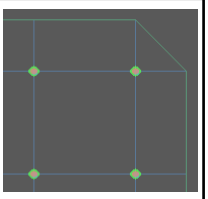
Format details continue on the next page.

Format details continued

Section/element	notes/description
[debug]	Extra features for debugging or understanding the operation of the software
layout = minimal server_print sens_print print	**full** – show all sensor config visually in the terminal with taxel arrangement *(default since 1.7.6)*  **File**: Shows which file the data was loaded from. In case of multiple files with the same name, it helps to troubleshoot. This is necessary when working with several definition file versions. **Description**: Shows info about the sensor. With some fully calibrated sensors, it will also state ownership **Modules**: Shows available modules and their statuses. To change the status, add the name in brackets to the [sensorN] section of the INI file and assign **ON** or **OFF** as a value. I.e. *magcomp = on* **Layout**: Shows info about taxel arrangement, including HEX ID and CAN channel sequence (with Multi-CAN, it helps to determine to which CAN the specified sensor belongs to **minimal** – only show specifics about sensors (ID, Size and Type)  **none** – do not show any info about sensors in the terminal
visual	*(experimental)* **on** - show detailed debug info in the visualiser **off** - no detailed info shown *(default)*

Format details continue on the next page.

Format details continued

Section/element	notes/description
[viz]	Specific settings only for XELA Visualizer
	
max_offset = 100	Defines how far the “bubbles” will go in visualisation 100 is the gap between 2 taxels (bubbles) in idle
max_size = 100	Defines the maximum size of the “bubbles” in the visualisation 100 is the gap between 2 taxels (bubbles) in idle
arrows = full	Defines if arrows are shown: **full** - show from the origin to the centre of the new position **half** - show from the origin up to halfway to the centre of the new position **none** - hide all lines between origin and new position
grid = on	Defines if the grid of the sensor is shown: **on** - shown **off** - hidden *Some sensors will have a custom grid that helps to understand them better* 
origins = on	Defines if origin points are shown: **on** - shown **off** - hidden
transparency = on	Defines if taxels have transparency: **on** - shown **off** - hidden **Note:** it can be taxing on the CPU without a dedicated GPU

Format details continue on the next page.

Format details (for [viz]) continued

Section/element	notes/description
fps = on	Defines if the visualisation window shows FPS counter for its re-draw rate In HW mode, it will try to match the screen refresh rate In SW mode, it will show the total maximum re-draw rate The default mode is HW since 1.7.7 Supported values for this setting: **on** - shown **off** - hidden (default) **Note**: can also be defined under [sensor] and [sensor*N*] sections **Note**: should only be enabled if visualisation performance is low and running in software mode has no change
ups = on	Defines if the visualisation window shows a UPS counter for sensor update rate It will only be shown if the server broadcasts the information Supported values for this setting: **on** - shown **off** - hidden (default) **Note**: can also be defined under [sensor] and [sensor*N*] sections
temp_show = on	Defines if temperature info is shown **on** - shown (default) **off** - hidden **Note:** will only be shown if supported by sensor and server

Format details continue on the next page.

Format details continued

Section/element	notes/description
[sensor]	Details about the default sensor (unless overridden in [sensor*N*])
num_of_sensor = 2 num_brd sensors num_of_sensor	Defines the number of sensors to be broadcast by the server. If using multiple small (1x1, 2x1, 2x2) sensors on a single controller, the sensors different from the first must specify it, i.e. channel=2
version = 3 ctrl_ver controller_ver controller_version ctr_ver	Defines the controller version By default (if not specified), it will be 3. Version 1 was supplied in 2018 - early 2019 only. Version 2 and 3 have different X, Y, and Z resolutions (15/16 bit HW)
model = XR1944 mdl	Defines the sensor model (or serial number) The default ones are: **XR1844** - old 4 channel 16 taxel sensor (no longer sold) **XR1944** - new 2 channel 16 taxel sensor (no longer sold) **uSPa11** - 1x1 sensor (formerly XR1911) **uSPa21** - 2x1 sensor (formerly XR1921) **uSPa22** - 2x2 sensor (formerly XR1922) **uSPa46** - 4x6 sensor (formerly XR1946) **uSPa44** - 4x4 sensor (formerly XR2144 and XR2244 with additional features) **Individually calibrated sensors** - will have the serial number here
id = 6 ctr_id controller_id ctrl_id	Defines the controller ID It must be written in decimals, such as numbers 0 to 15.
channel = 0 chan sda	Defines the starting channel (SDA) for the sensor
taxel = 0 txl	Defines the taxel ID offset It must be written in decimals, such as numbers 0 to 15. Used with some uSPa 11/21/22 sensors
format = formatted data_format	Defines if formatting on the server is enabled or the raw info is broadcast (setting it to raw will disable most functions) **modified** - (default), all axes will be set by the server to be the same across all sensors **raw** - all axis, as shown in the hardware manual, can become very confusing when using several different sensors

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Format details continued, section [sensor]

rotation = 0 rot rotation	Defines how much the sensor will be rotated for adjustment **0** - no rotation **1** - 90 degrees clockwise **2** - 180 degrees **3** - 90 degrees anti-clockwise **NOTE: Some modules will conflict with rotation**
module_name = off	Enable or disable custom modules supported by the sensor model. Most modules are off by default. **off** - force the module to be disabled **on** - force the module to be enabled Example modules: ***magcomp*** - magnetic compensation ***clustering*** - calculated touch clusters ***calibration*** - force calibration **Warning**: Enabling modules not supported by your hardware can cause invalid data.
temp_id = XYZABC	To load temperature compensation parameters for the sensor. XYZABC stands for the filename without the .xtp extension. A tool that allows customers to calibrate the temperature compensation themselves will be available in the future, and that tool will make this file.

Format details continue on the next page.

Format details continued

Section/element	notes/description
[sensor*N*]	Contains only details that override the default sensor; check alternative naming from [sensor]
version = 3	Defines the controller version
model = uSPa44	Defines the sensor model
id = 6	Defines the controller ID
taxel = 0	Defines the taxel offset
channel = 0	Defines the starting channel (SDA) for the sensor
format = formatted	Defines if formatting on the server is enabled or the raw info is broadcast (setting it to raw will disable most functions)
rotation = 0	Defines how much the sensor will be rotated for adjustment **0** - no rotation **1** - 90 degrees clockwise **2** - 180 degrees **3** - 90 degrees anti-clockwise
module = off	Enable or disable custom modules supported by the sensor model. Most modules are off by default. **off** - force the module to be disabled **on** - force the module to be enabled Example modules: ***magcomp*** - magnetic compensation ***clustering*** - calculated touch clusters ***calibration*** - force calibration Warning: Enabling modules not supported by your hardware can cause invalid data.

CAN types

esd

As default for esd CAN-USB/2 uses *ntcan* drivers provided by esd as Windows lacks support for standardised CAN. The user is required to install the latest drivers and SDK found on the esd.eu website.
Channels are numeric and can be defined in Device Manager to support several devices on the same PC.

pcan

Most PEAK devices use a non-standardized communication protocol between the PC and CAN converter. It works both in Windows and Linux.
Channels are named based on the device type and sequence, i.e. PCAN_USBBUS1.
Note: In the newer Linux kernel, PEAK has been added to the kernel and will follow default socketcan practices.

slcan

SerialCAN for Windows, covering devices like VScom's USB-CAN Plus.
Channels are COM ports shown in the Device Manager.

socketcan

Default for Linux, covering most CAN and SerialCAN devices. Some PEAK devices can also work under this setting.
Channels are actual *can* and *slcan* buses in the format of can*N* or slcan*N.*
Note: In the newer kernel, the SerialCAN is in the kernel and will use *canN* naming.

sim

A simulated CAN device tries to match the maximum CAN messages expected from any sensors.
If the channel is "sequential", the output will have a sequence based on the computer time, starting every 15 seconds. It affects only X and Y values; Z is random. The sequence is as follows:

1. 4 seconds of tiny changes (wiggly mode)
2. 2-second intervals of 4 diagonal directions each (centre-to-corner movement)
3. 3 seconds of complete randomness

With any other value on the channel parameter, it will produce random values for X, Y and Z.

Special sensors

Standard and Individually calibrated sensors

Prerequisites

- Software version 1.7.5 or newer
- Fully calibrated sensors with serial numbers or sensors supporting the calibration
- Calibration and definition files

Sensor compatibility:

Sensor model	Standard calibration*[1]	Individual calibration (extra file needed)
uSPa44	✔	✔
uSPa46	✔*[2]	✔
uSPa22	✔*[3]	✔

File compatibility:

Software version	.xeladef	.xdef	.xela	.xcal
1.7.5	✔	✖*[4]	✖	✔
1.7.6+	✔	✔	✔	✔

Generic parameters for uSPa44 are included with the software 1.7.6+
.xcal file is not required if using 1.7.6+ with .xela file unless the user needs to adjust the parameters themselves

[1] For sensors getting standard calibration after software release, can be manually added with an additional file. 1.7.6 release includes standard calibration only for uSPa44
[2] Added to 1.7.7 build 161703
[3] Added to 1.7.7 build 161703
[4] Some .xdef files might work in 1.7.5 release, but are not recommended

Setup

1. Copy the provided files (.xela, .xcal) to the following directory:
    a. /etc/xela/sensors directory (Linux)
    b. the same directory you have the application in (Windows)
2. Edit the INI file to contain the following info:
    a. `model = S/N` (only for fully calibrated sensors), otherwise `model = model_name`
    Examples: `model = XC166EC61` for fully calibrated sensor and `model = uSPa44` for standard calibration on uSPa44
    b. `calibration = on` (only required for standard calibration)

Notes

Comparing Sensor Calibration: Generic vs. Individual

In this software manual, we explore two calibration variants of the uSPa44 (XR2244) sensor: Generic Calibration and Individual Calibration. They both have the same purpose but with some significant differences.

Generic Calibration:

Generic calibration is a standardised approach calculated based on data collected from multiple sensors of the same type. These parameters are designed to provide a baseline level of performance suitable for a range of applications.
Key points to note about Generic Calibration:

Simplicity: Generic calibration ensures a simple activation method by writing a simple line in the INI file compared to changing every model name to a serial and managing extra files.

Immutable Parameters: Generic calibration parameters are set during manufacturing and remain fixed. They are not user-adjustable or accessible from the software interface. This means they are invisible to the user and cannot be modified.

Individual Calibration:

On the other hand, individual calibration is a highly tailored approach explicitly performed on the uSPa44 (XR2244) sensor in question. These parameters are fine-tuned to the unique characteristics of this particular sensor.
Here's what sets Individual Calibration apart:

> **Precision**: Individual calibration offers superior precision and accuracy. It optimises the sensor's performance to its full potential, ensuring the most precise measurements.
>
> **Customizability**: One critical advantage of Individual Calibration is its flexibility. Users can modify and fine-tune parameters to suit their application's specific requirements. This means you can adapt the sensor to various tasks or conditions, providing a higher level of control.
>
> **External Access**: Individual calibration parameters are accessible from the software interface, allowing users to make real-time adjustments. This added functionality empowers users to fine-tune the sensor's behaviour on the fly.

Forces Up to 5N:

It's important to note that Generic and Individual Calibration methods have been calculated with forces up to 5N for each sensing point. This ensures your sensor maintains its precision and reliability within this specified force range.

With all calibration, you need to edit the xServ.ini file manually.
For generic parameters (like with uSPa44 sensors), you need to add `calibration = on` under the `[sensor]` or `[sensor`*N*`]` section to enable the output
For individual parameters, you must change the model to the serial number. I.e. instead of `model = uSPa44` you will write `model = XC166EC61`

Data

All calibrated data is available as part of the sensor message. Please see an example below with the information highlighted:

{'message': 786, 'time': 1619157045.6195483, 'sensors': 2, '1': {'data': 'FA00,...,FC00', 'sensor': '1', 'taxels': 4, 'model': 'uSPa22', 'calibrated': null}, **'2'**: {'data': 'FB01,...,FC01', 'sensor': 2, 'taxels': 16, 'model': 'uSPa44', **'calibrated': [0.059,0.021,0.15,...]**}}

For more info about data format, please see paragraph Messages.

Note: The forces are in Newtons.

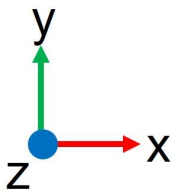
How to use parameters in other software

You will get the parameters in the XCAL file for individually calibrated sensors. They are in a table, where each row is for 1 taxel.
Note: Their sequence is based on the sequence provided by the Server software, so using them directly from the CAN bus would require making sure the correct taxel IDs first. Refer to the table at the start of the Server to see ID allocations.

The following formula can be used to calculate the force. The parameters are given in a list of 27 elements, 9 for each axis (X, Y, and Z), in the XCAL file.
Reminder: This is only available for individual calibration.

Read:
For x, p = params[0…8]
For y, p = params[9…17]
For z, p = params[18…26]
k stands for X, Y or Z

$$F_k = x_d{*}p_0 + y_d{*}p_1 + z_d{*}p_2 + x_d{*}y_d{*}p_3 + x_d{*}z_d{*}p_4 + y_d{*}z_d{*}p_5 + x_d^2{*}p_6 + y_d^2{*}p_7 + z_d^2{*}p_8$$



The parameters, by default, refer to the orientation stated in the hardware manual.
When using the server application, the forces will be adjusted to show in the normal XY plane as they are with regular measurement values corresponding to the image shown here.

Sensors with magnetic compensation

Prerequisites

- Software version 1.7.6 or newer
- Sensors with magnetic compensation support
- (optional) sensor .xdef or .xela files (if not included in the software)

Setup

- Copy the provided files (.xela or .xdef) to the following directory:
  - /etc/xela/sensors directory (Linux)
  - the same directory you have the application in (Windows)
- Edit the INI file to contain the following info:
  - `magcomp = on` under the `[sensor]` or `[sensor`*N*`]` section

Notes

It can be provided as an individual model or as a module for the current sensor model. For example, the uSPa44 has a variant with magnetic compensation, which can be activated by the INI file with `magcomp = on` under the same sensor configuration section.
Note: Applying magnetic compensation for sensors without this feature can cause invalid output.

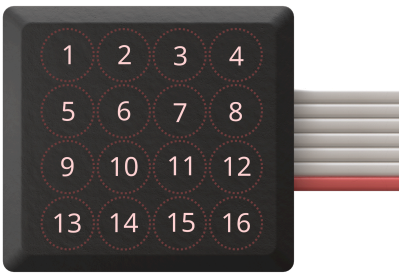
The configuration tool will recognise it as a standard sensor, and the user must change it in the INI file.

This sensor type has 2 extra settings that can be used in the INI file under the `[sensor]` and `[sensor`*N*`]` sections:

rawmode	On / off (default off)	Allows to see both compensated and raw data in the XELA Viz application. It also adds raw data to the message.
magcomp	On / off (default on)	Activates the compensation algorithm. In the data stream, it will replace the original data. Enable `rawmode` if you need the initial data.

Data format

Sensor Layout



Understanding Sensor Data

- Data Reading: The sensor data is read from left to right, starting at the top left corner and moving across each row.
- Multiple Sensors: If you connect multiple 4x4 sensors, the server will treat them as separate sensors. (If you need a different setup, please contact us for custom configurations.)

Determining Sensor Layout

- Orientation: Place the sensor flat in front of you with the cables coming out of the right side (or if it has a connector, have the connector on the right). This is the standard orientation.
- Layout: The image above shows the layout for a standard 4x4 sensor. If you have a 4x6 sensor, it will have two additional columns (numbers 5 and 6 in the first row).
- Curved Sensors: Curved sensors will be represented as if they were flat. Always keep the cable to the right and refer to the server layout for accurate positioning.

Server Configuration

To see the sensor layout in the server application:

1. Locate the INI file.
2. Find the [debug] section.
3. Set `layout = full` to enable the layout display.

Note: the sensor is considered up-right if the cables exit on the right (attachment) side.

Messages

As the data is provided in a JSON string, there are few ways to access it, and it has the following default format:


```
{
   "message": 49090,
   "time": 1708406349.5611684,
   "sendtime": 1708406349.5616164,
   "sensors": 3,
   "type": "routine",
   "1": {
      "time": 1708406349.5593173,
      "sensor": "1",
      "data": "8246,81A8,8A58,...",
      "model": "XR1944",
      "taxels": 16,
      "tempraw": [33337, 33205, 35607, …],
      "temp": [ 307.531, … ],
      "ups": [105.17100960863372, …],
      "calibrated": [0.059, 0.021, 0.15, …]
   },
   "2":{
      …
   },
   …

}
```


Explanations

message has the sequence number of the broadcast (to avoid outdated messages)

time has a UNIX timestamp of data creation

sendtime has a UNIX timestamp of publishing time

sensors mentions the total amount of sensors the server is handling currently

type mentions the message type; it can be “routine”, “on-update”, or “welcome”

- “routine” will show on messages sent out by the server in a specified frequency
- “on-update” will show on messages that are only sent out when a sensor update occurs
- “welcome” will show on the first message sent out by the server after connecting

(continues on the next page)

(sensor message explanations continued)

Each sensor will have its data under the element with its number, in this example, “1”:

time shows the last update that was calculated on the sensor, relies on the CAN messages

data contains X, Y and Z data for all taxels (sensing points) in order, converted into HEX values (without leading ‘0x’) as text. It means that it will need to be parsed after receiving

sensor has the number of the sensor in string format (redundancy check)

taxels has the number of the taxels meant to be sent (for confirmation only)

model shows the correct sensor model as a reference

calibrated shows the calculated forces applied to the sensor (if supported by the sensor via XCAL files and enabled in the INI file)

tempraw shows the raw sensor values before temperature compensation (if supported by the sensor and enabled in the INI file)

temp shows the sensor temperature for each taxel in Kelvin (can also be shown in the visualization application by enabling it in the INI file, only with sensors that have external temperature compensation)

ups shows the estimated update rate of the sensor for each taxel (useful with event-driven sensors to detect increased activity)

Example usage

Code

```
#!/usr/bin/env python3
import websocket
import json
from time import sleep
import threading

ip = "192.168.0.103" #your computer IP on the network
port = 5000 #the port the server is running on

lastmessage = {"message":"No message"} #default message you will overwrite when you get update
def on_message(wsapp, message):
    global lastmessage #globalise to overwrite the original
    try:
        data = json.loads(message)
    except Exception:
        pass
    else:
        try:
            if data["message"] == "Welcome":#get the Welcome Message with details, print if you like
                print(data)
            else:
                lastmessage = data
        except Exception:
            pass #ignore message as it's probably invalid
def threader(target, args=False, **targs):
    #args is a tuple of arguments for a threaded function; other key-value pairs will be sent to Thread
    if args:
        targs["args"]=(args,)
    thr = threading.Thread(target=target, **targs)
    thr.daemon = True
    thr.start()
def mesreader():#this is your app reading the last valid message you received
    while True:#to run forever
        try:
            if lastmessage["message"]!="No message":
                print("I received: {}\n--------".format(str(lastmessage)))
            sleep(0.5) #your calculations and processes here (sleep is used as simulation here)
        except KeyboardInterrupt:
            break #break on KeyboardInterrupt
        except Exception as e:
            print("Exception: {}: {}".format(type(e).__name__,e))
    try: #try to close the app once you press CTRL + C
        wsapp.close()
    except Exception:
        exit()
threader(mesreader,name="Receiver") #start you main app
websocket.setdefaulttimeout(1) #you should avoid increasing it.
wsapp = websocket.WebSocketApp("ws://{}:{}".format(ip,port), on_message=on_message)#set up WebSockets
wsapp.run_forever() #Run until the connection dies
exit()
```

Common errors

Error	Reason
Anti-virus software sees the applications as potential malware or virus	Due to Python (the language in which the entire application suite is written) being interpreted language, most AV software cannot differentiate between malware and regular applications that use sockets. To avoid this, we would need to rewrite the whole application suite in other languages, which is also planned for the 1.8.0 release. It will be worked on to remove false positive flagging
XELA_Conf found the sensor, and XELA_Server is working with no errors, but there is no XELA_Viz visual output (Windows)	The AV software may interfere with the software's networking by not letting the Visualizer connect to the Server. Turn off the AV software and try again
XELA_Conf is giving: Message not sent: OSError: Transmit operation timed out	Make sure the power USB is connected to a power source and the DSUB9 is firmly attached to the CAN-USB converter
Could not start CAN: OSError: [Errno 19] No such device	Make sure to pull up the network with one of the following commands if using Linux: user@localhost:~$ sudo ip link set up can0 type can bitrate 1000000 or user@localhost:~$ sudo slcand -o -s8 -t hw -S 3000000 /dev/ttyUSB0 user@localhost:~$ sudo ifconfig slcan0 up In the case of Windows, make sure the adapter is connected and using the specified channel (esd channel might not be 0)
Program not responding to CTRL+C	There are times when the apps might not correctly respond to CTRL+C. In those cases, you can try the following: **Linux:** Ctrl-Shift-\ or pkill -9 xela_server (or whichever function is not responding) **Windows**: CTRL+Pause_Break or you can simply close the app
Error connecting to CAN: IOError:[Errno 19] No such device	No CAN device was found. Make sure your CAN-USB device is connected, drivers installed for it, accessible for all users (pulled up) and set in the configuration file correctly (see /etc/xela/xServ.ini or xServ.ini)
Error writing config file: IOError: [Errno 2] No such file or directory: '/etc/xela/xServ.ini'	Ensure there is a /etc/xela folder (in Linux or an executable folder in Windows) and that it has 777 permissions

Unable to install Python 3.7 or newer on Ubuntu	To install different Python versions on Ubuntu, use the deadsnakes repository: `sudo add-apt-repository ppa:deadsnakes/ppa`
XELA_Viz fails to launch Showing ImportError	Possible reasons are that your computer software or hardware is incompatible with SDL2 libraries inside the executable. We recommend using a different computer for visualisation in such a case, preferably running Ubuntu 20.04 (similar happens when running Ubuntu 16.04 app in newer Ubuntu release. Check release with `uname -a`) A similar error on Windows means missing Visual C++ redistributable 2015-2019 x64. Please install it, restart the computer and try again
The new CAN-USB converter is not working with the software	Please make sure the following steps: ● CAN-USB device is supported in the OS you are using ● You have selected the correct bus type in the configuration file (socketcan/esd/pcan) ● You have selected the correct channel in the configuration file (can0/slcan0/COM3, etc.) ● Make sure the network is pulled up (Linux only) ● ctrl_id matches with the hardware

If you find errors not listed in this file, please send an email regarding it to info@xelarobotics.com
Do not forget to attach files from the /etc/xela/LOG directory in Linux or the LOG directory in Windows (if using the default log directory), a description of the failure, and additionally, you can add the terminal log (if log directory is empty, as a text, not image). If you have made your own code causing errors, please attach it.

Known issues

Visualization

- Sometimes, it fails to reconnect to the server (under investigation)

Server

- Crash if esd Net Bus ID is wrong or esd CAN-USB/2 is not connected (limitation of the current ntcan library, Windows only)

Configurator

- Only supporting uSPa 44/46 sensors (will be added in the future)

How to report issues (checklist)

- [ ] Have you checked the messages provided in the terminal to see if there is a missing file or permission errors
- [ ] Have you checked if the sensors are connected to the PC and powered on
- [ ] Have you read the manual fully to see if anything is missing (i.e. server in simulation mode)
- [ ] Have you attached all log files to the email
- [ ] Have you added additional info covering what steps have been taken to resolve the error on your own
- [ ] Have you provided terminal output in text files attached to the email

Once all is checked, feel free to send the email to info@xelarobotics.com
Reminder: we might request additional details and info before being able to fix your issue