Design and Implementation of a Smart Floor with Topology Reconstruction

User Manual

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1 Introduction

This user manual describes how to connect, start, and use the smart floor system. The system is built from several modular floor nodes. Each node contains force sensors, communication connectors, and electronics for reading sensor data and sending it to the graphical interface.

The user connects the nodes with UTP cables, connects the root node to a computer over USB, powers the system with an external power supply, and starts the graphical interface. The graphical interface then reconstructs the node topology and displays the floor layout together with live sensor data.

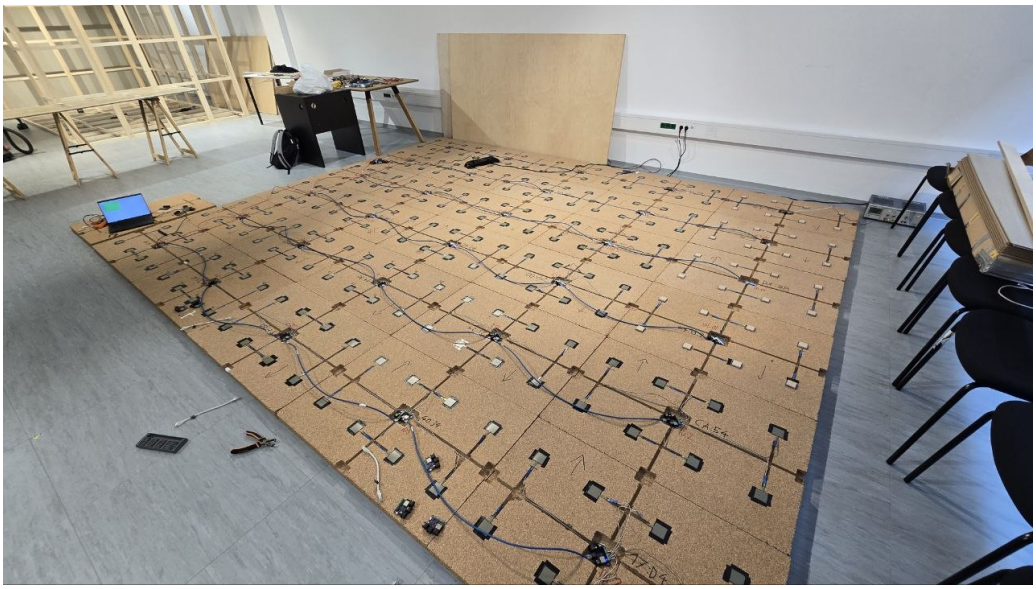

Figure 1: Example of the assembled smart floor system.

2 System Components

The smart floor system consists of the following main components:

- smart floor nodes,
- UTP cables for communication between nodes,
- root node connected to the computer,
- Micro-USB cable for connecting the root node to the computer,
- external power supply,
- graphical interface application,
- computer with Java 21 installed.

Each node has several ports. The ports are used to connect the node to its parent node, child nodes, or the power supply. The root node is the main node of the system and is connected directly to the computer.

3 Connecting the Nodes

Nodes must be connected using UTP cables with a maximum length of 2 meters. The topology is built as a tree. The root node is placed at the beginning of the topology and can be connected to up to two child nodes. The input port of the root node is connected to the output ports of its child nodes, if those child nodes exist.

The same rule is then applied to the child nodes. Each child node can also have its own children connected in the same way. This creates a tree-like connection between all nodes.

When connecting the nodes, the user should make sure that:

- UTP cables are not longer than 2 meters,
- the root node is connected correctly,
- each child node is connected to the correct parent node,
- the cable connections are fully inserted,
- the physical layout matches the intended floor setup as much as possible.

4 Connecting the Root Node to the Computer

After the nodes are connected together, the root node must be connected to the computer. This is done with a Micro-USB cable connected from the root node to a USB port on the computer.

The computer must recognize the USB-to-UART converter on the node. The board uses a CH343G USB-to-UART converter. On some systems, especially Windows, a driver may be required. The driver can be downloaded from the following link:

`https://www.wch-ic.com/downloads/CH341SER_EXE.html`

After the driver is installed, the device should appear as a serial port. On Windows this is usually shown as a COM port. On Linux or macOS it usually appears as a serial device under `/dev/`.

5 Powering the System

The system also requires external power. The power supply uses the same type of UTP cable as the node connections. The power supply cable can be connected to any node port, either input or output. It does not matter which port is used for power.

It is recommended to connect the power supply somewhere near the middle of the floor layout. This helps distribute power more evenly across the connected nodes.

Before starting the graphical interface, check that:

- the power supply is connected,
- the UTP power cable is properly inserted,
- the root node is connected to the computer,
- all node-to-node cables are connected.

6 Starting the Graphical Interface

The graphical interface requires Java 21. After Java 21 is installed, the application can be started from the terminal with the following command:

```
java -jar smart_floor.jar
```

When the application starts, it lists the available serial devices in the top-right part of the window. The currently selected device is shown under the **Port** option. This field is a drop-down menu, so the user can select the correct serial port if more than one device is connected.

After the correct port is selected, the graphical interface receives data from the root node. The nodes and their connections are reconstructed automatically and shown in the main window.

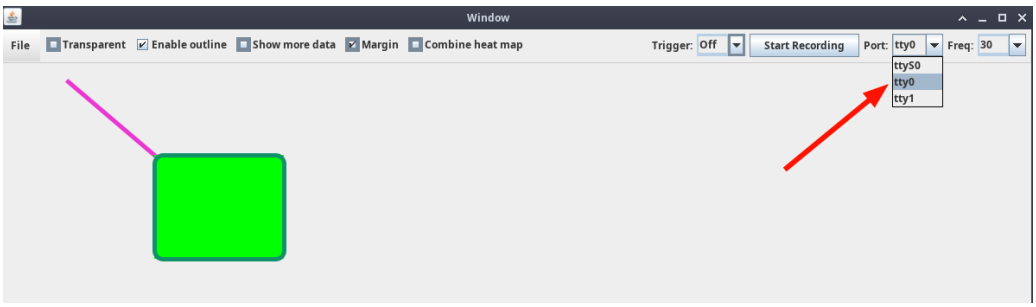

Figure 2: Serial port selection in the graphical interface.

7 Main Window

The main window shows the reconstructed floor topology. Nodes are displayed as floor modules, and their connections are shown according to the detected topology. If the topology reconstruction is successful, the displayed layout should match the connected floor structure.

The user can move nodes with the mouse. This is useful when the automatically reconstructed topology does not show the exact desired visual shape. The topology still remains the same, but the user can adjust the visual position of the nodes for better readability.

If the user wants to keep the adjusted layout, it can be saved through the **File** menu by selecting **Save**. A previously saved layout can be loaded through the same menu by selecting **Open**.

8 Display Options

The graphical interface includes several display options in the top-left part of the window. These options can be used to make the visualization clearer or to show additional information.

The outline option can be enabled to make node borders more visible. This is useful when the heat map colors make it harder to see the shape of individual nodes.

The heat map shows sensor values on each node. There is also an option to combine the heat map. When the combined heat map option is enabled, the heat map spreads to nearby nodes, which creates a smoother visualization across the floor.

The transparency option can be used when nodes overlap visually. Lower transparency makes it easier to see nodes that are placed on top of each other. The margin option changes spacing between nodes. It can be used to make nodes stick together or separate them for better visibility.

Figure 3: Display options in the graphical interface.

9 Frequency Setting

The graphical interface also contains a frequency setting in the top-right part of the window. This setting controls the frequency used by the system when reading or updating data. The user can adjust this value depending on the testing needs.

A higher frequency gives faster updates, while a lower frequency can be useful when the user wants slower or more stable visualization during testing.

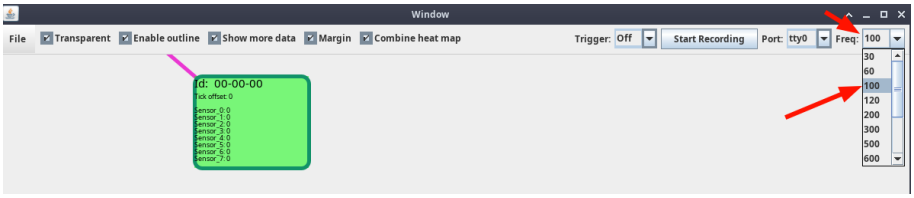

Figure 4: Frequency setting in the graphical interface.

10 Viewing Sensor Data

The user can click on a node in the main window to open a graph window. This graph displays data from the sensors on the selected node. The values are shown in newtons, so the user can observe how much force is applied to each sensor.

This view is useful for testing whether the sensors work correctly and for observing the force distribution on a specific node.

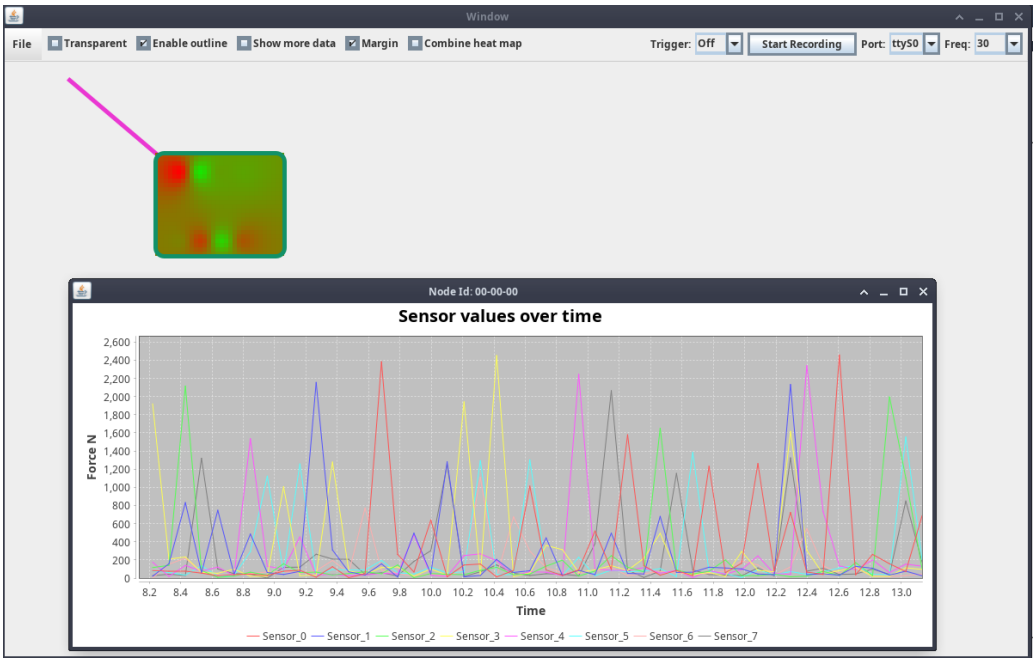

Figure 5: Graph window showing sensor force values for a selected node.

11 Recording Data

The graph window includes a **Start Record** button. By clicking this button, the user can start recording sensor data to a CSV file. The recorded file contains timestamps, node IDs, raw sensor values, and calculated force values.

The CSV file uses the structure shown in Table 1.

Table 1: Example of recorded CSV data

Timestamp	NodeID	Sensor0	Sensor1	Sensor2	Sensor3	Sensor4	Sensor5	Sensor6	Sensor7	Force0	Force1	Force2	Force3	Force4	Force5	Force6	Force7
2025-08-01 21:47:21.366	D0-4B-68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2025-08-01 21:47:21.365	D0-4B-80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2025-08-01 21:47:21.364	D0-4B-84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2025-08-01 21:47:21.363	D0-4B-74	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2025-08-01 21:47:21.362	C9-8E-4C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2025-08-01 21:47:21.365	C9-8E-34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2025-08-01 21:47:21.364	C9-8E-48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2025-08-01 21:47:21.363	D0-4B-88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2025-08-01 21:47:21.362	C9-8E-6C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2025-08-01 21:47:21.363	C9-8E-68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

This file can later be used for analysis, debugging, or comparison between different tests.

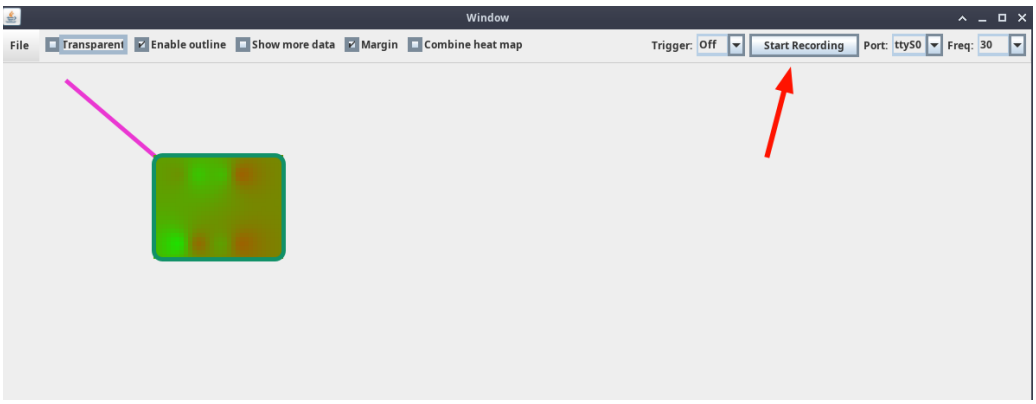

Figure 6: Start Record button used for saving sensor data to a CSV file.

12 Troubleshooting

Problem	**Possible solution**
No serial port is shown in the GUI	Check the Micro-USB connection, power connection and install the CH343G/CH341 driver if needed.
Some nodes are missing	Check UTP cable connections.
Sensor values do not change	Check the selected serial port, node power, and sensor connections.