User Manual

Henrik Ahlinder, Sebastian Andersson, Martin Dahl, Christian Gustavsson,
Joel Henneberg, Tiger Kylesten.

December 16, 2022

Version 1.0

Status

Reviewed	Martin Dahl	2022-12-09
Approved	Danyo Danev	

Project Identity

Group E-mail: CDIOProjektgrupp@liuonline.onmicrosoft.com

Homepage: wavecounter.xyz

Orderer: Danyo Danev
Phone: +46 (0)13 28 13 35
E-mail: danyo.danev@liu.se

Customer: Danyo Danev
Phone: +46 (0)13-28 13 35
E-mail: danyo.danev@liu.se

Supervisor: Sai Subramanyam Thoota
Phone: +46 (0)13-28 68 59
E-mail: sai.subramanyam.thoota@liu.se

Course Responsible: Danyo Danev
Phone: +46 (0)13-28 13 35
E-mail: danyo.danev@liu.se

Participants of the group

Name	**Role**	**E-mail**
Christian Gustavsson	Project Manager, PM	chrgu102@student.liu.se
Henrik Ahlinder	Interface Manager, IM, and deputy CD	henah490@student.liu.se
Joel Henneberg	Chief of Hardware, CH, and deputy PM	joehe862@student.liu.se
Martin Dahl	Documentation Manager, DM	marda545@student.liu.se
Sebastian Andersson	Test Manager, TM	seban218@student.liu.se
Tiger Kylesten	Chief of Design, CD	tigmo832@student.liu.se

CONTENTS

DOCUMENT HISTORY

Version	Date	Changes made	Sign	Reviewer
0.1	2022-11-18	First document skeleton	PM	
1.0	2022-12-09	Delivery to customer	PM	Group

1 INTRODUCTION

Welcome! This is the User manual for the WaveCounter system - The accurate and non-intrusive way to keep track of people in your facility.

Step-by-step, it will guide you through the setting up of both the software and the hardware devices. We will also guide you through the graphical user interface and cover the basics of the available models that come pre-installed and adapted for your use case. Some initial suggestions on how to test the implementation will also be provided.

Note that the product is trained in the specified environment. It will be useful also in other settings, but effectiveness can not be guaranteed. To achieve good performance, don't hesitate to contact your WaveCounter representative. WaveCounter can present a suggestion for how to proceed with maintained accuracy.

Let's Go!

2 GETTING STARTED

The program is designed to work with Linux, but might work with other operating systems as well. To run the program Docker, docker compose and make is also required. To get docker, follow the instructions on https://docs.docker.com/engine/install/, and to install docker compose follow the instructions on https://docs.docker.com/compose/install/other/.

Starting the program is a simple three-step process:

1. Start a terminal in the directory where the source files are
2. Run the following commands:
   a) make build
   b) make init
   c) make run
3. To access the user interface, open a browser and enter 'localhost:3000' in the search bar.

3 SETTING UP

To get the most out of your WaveCounter, we recommend using it in a environment as similar as possible to the environment where the development of the product took place. This section aims to provide a description of the enviroment where the WaveCounter was trained.

Figure 1: Picture of the ADALM-PLUTO units.

3.1 The environment

The WaveCounter is trained on data collected in a room located at Campus Valla in Linköping. If you wish to visit this room to see it in person it is located in house B, entrance 29 and it is room 3A:462. The room is a small office with a corridor directly outside. The doorframe in which the ADALM-PLUTO devices has been mounted in is a regular sized doorframe with a width of around 90 cm.

3.2 The setup

When setting up the product it is important that the ADALM-PLUTO devices is set up correctly, otherwise the Wave-Counter might not yield satisfying results. To set everything up correctly, carefully follow the steps below:

1. Take the ADALM-PLUTO devices, their power cords and antennas out of the box.
2. Mount the antenna marked ”Rx“ on the device marked ”Rx“ and the antenna marked ”Tx“ on the device marked ”Tx“ according to 1. Mount the antennas so that they point straight upwards if the devices are lying flat on the ground. Place the one marked as "Tx" on the side of the doorframe which is on your right when walking in through the door.
3. Place the ADALM-PLUTO devices on each side of the desired door frame, on a height where the lower edge of the devices are 29 cm ($\pm$ 1 cm) above the ground.

4. Plug in the power cord in the middle socket at the bottom of the ADALM-PLUTOS's and plug them into a computer. Note that it is often practical to use a USB-adapter to get more range out of the cords so that the computer can be at some distance from the doorframe.
5. Make sure to fix all the cords in a way so that it is safe to pass through the door without tripping.

Figure 2: Picture of what the setup should look like.

4 OVERVIEW OF THE USER INTERFACE

The user interface is hosted as a web application. This section describes the different parts of the User Interface and how to use it. The user interface consists of two different pages named *Home* and *Live*. The first is used for collecting data to potentially train models on and the second to use the product to measure the number of persons passing through a doorway.

To switch between *Home* and *Live*, simply press the desired mode in the menu that you find at the center in the upper most part of the user interface.

4.1 Home

In this part of the user interface you can create schemas for data collection, create datasets and collect data. Collected data can be sent to the WaveCounter developers for the training of new models, customized and suitable for your specific environment.

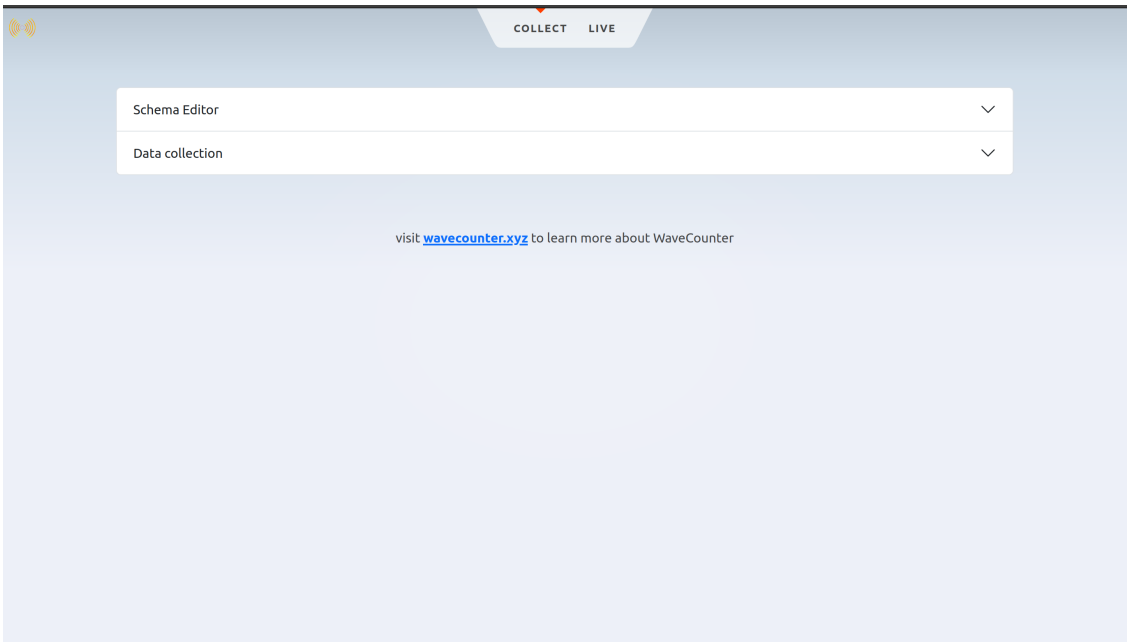

Figure 3: The Home page in the user interface.

4.1.1 *Schema Editor*

Schemas are used to identify what type of data is in a data collection. A schema is supposed to contain all relevant information that developers could use to optimally train new models using the data connected to the schemas that you have created.

To create schemas used for data collection, press *Schema Editor*, and you will see the view of figure 4 on your screen. To see which schemas are already created and ready for use, press the dropdown menu at the top named *Schemas*. Observe that even though it is possible to define a schema with both the "In" and "Out" field set with non-zero integers at the same time and also to set either of the fields value to other than 0 or 1, this is not recommended and currently not supported by the application.

If you want to create a new schema, fill out *Schema name*, *In*, *Out* and *Description*. Be sure to be clear and systematic when creating schemas so it is obvious what the schema means.

There are also buttons for resetting and deleting schemas. If you want to use any of these functions, simply choose the desired schema and press either *Reset Schema* or *Delete Schema*.

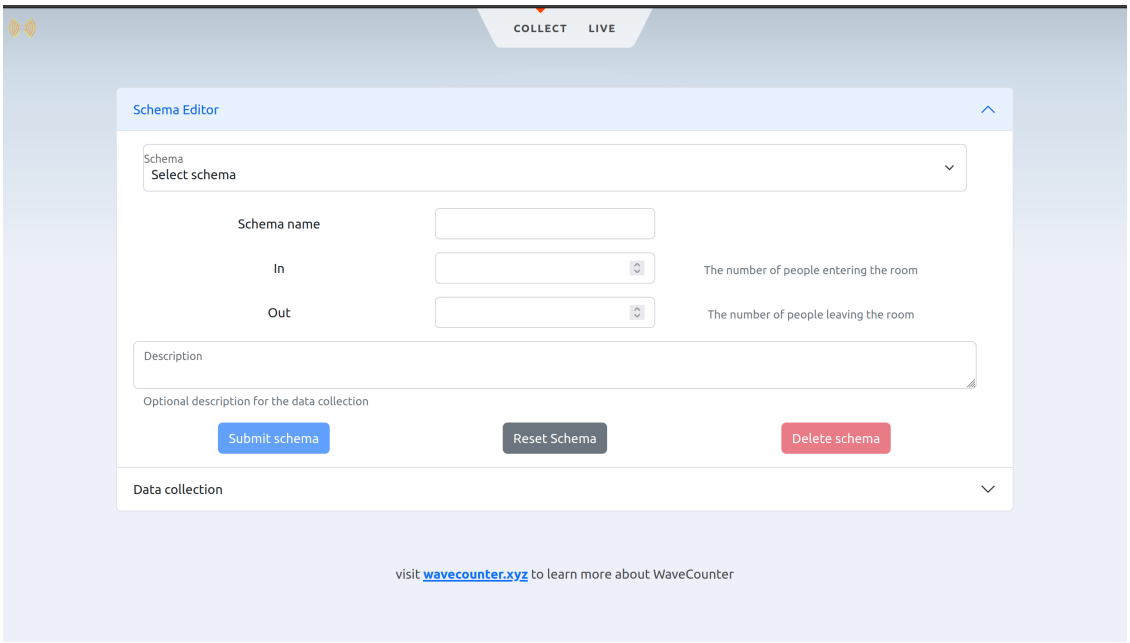

Figure 4: Schema editor in the user interface.

4.1.2 *Data collection*

The *Data collection* part of this mode is for choosing and creating dataset, choosing schemas and the amount of samples you want to collect. When these fields are filled with valid entries, simply press the *Start Collection*-button to start collecting data. The system will then start to calibrate and when finished it will play a low beep sound and start collecting the first data sample according the starting schema (the first schema entry). During the following five seconds a high beep sound will be played each second and data will be collected, then a low beep sound will be played once again and data according to the second schema entry will be collected. This will iterate and alternate between the two schemas until the set number of samples have been collected.

The data collected can be found in your WaveCounter's directory, more specifically in *wavecounter/data/<Dataset-Name>*.

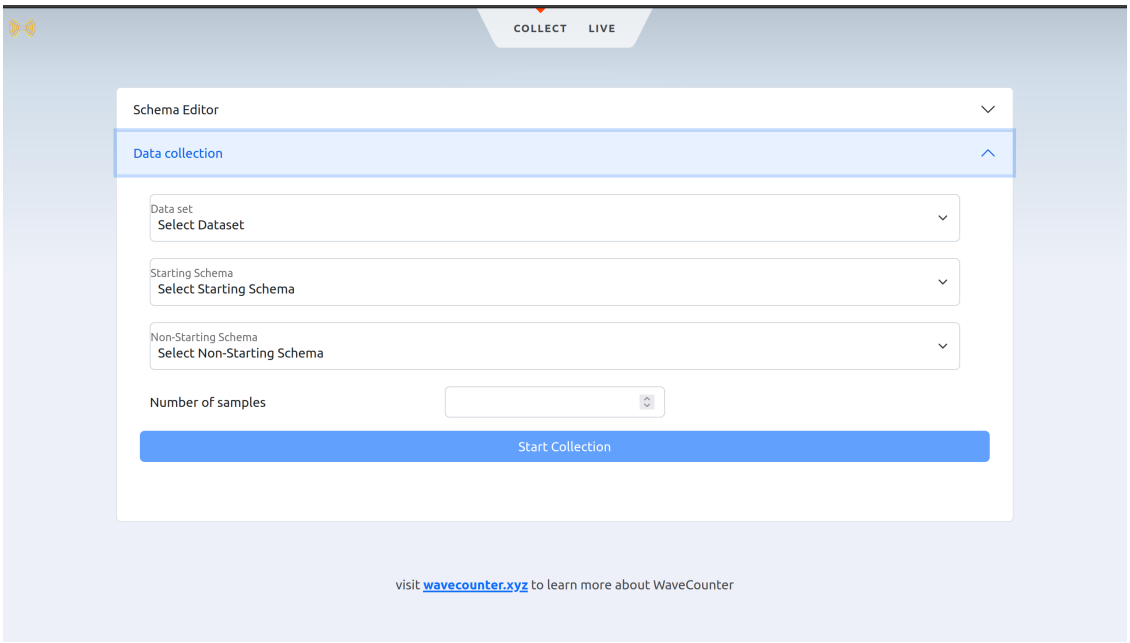

Figure 5: Data collection in the user interface.

4.1.3 *Data collection - An example*

Here we will give an example of how to set up schemas and datasets before doing a data collection for a cat's walking direction through a door that leads into a bedroom.

Schema: Create two schemas according to table 1.

Schema name	Cat_in	Cat_out
In	1	0
Out	0	1
Description	Cat walking in	Cat walking out

Table 1: Table over example schema entries.

Data collection: Choose the number of samples you want to collect. For the sake of the example, make sure to choose "Cat_in" as the first schema entry and "Cat_out" as the second schema entry. Also choose "+add dataset". Name the new dataset "Cat_Bedroom" and give it a proper description, e.g "A cat walking in and out of the bedroom".

Press *Start Collection* and wait for the calibration to finish. Once you hear the low beep sound, make sure the cat passes through the door and walks into the bedroom within five seconds. When you hear the next low beep, make sure the cat passes out through the door within the next five seconds. Iterate this process and let the cat walk in and out of the door until all samples have been collected.

4.2 Live

This is the part of the user interface in which you can run your WaveCounter in real time, or test how different models perform on pre-collected datasets.

To the top left you can choose a trained model used to classify in which direction the object is moving. When a model is selected, relevant metrics are displayed below the dropdown. In the top middle there are two counters, one for the number of predicted in passages, and one for the number of predicted out passages. The top right contains a field for selecting collected datasets to evaluate the selected model on. Below there are two plots displaying the live feed of the signal to the left, and the signal of the last prediction.

In the bottom there are three buttons. “Single Sample” is used to collect until someone passes through the doorframe, do a prediction and then stop. “Start” is used to start a continuous collection and predict each passage through the doorframe. “Stop” can then be pressed to stop the continuous mode. “Reset” is used to reset the counters displaying the predictions.

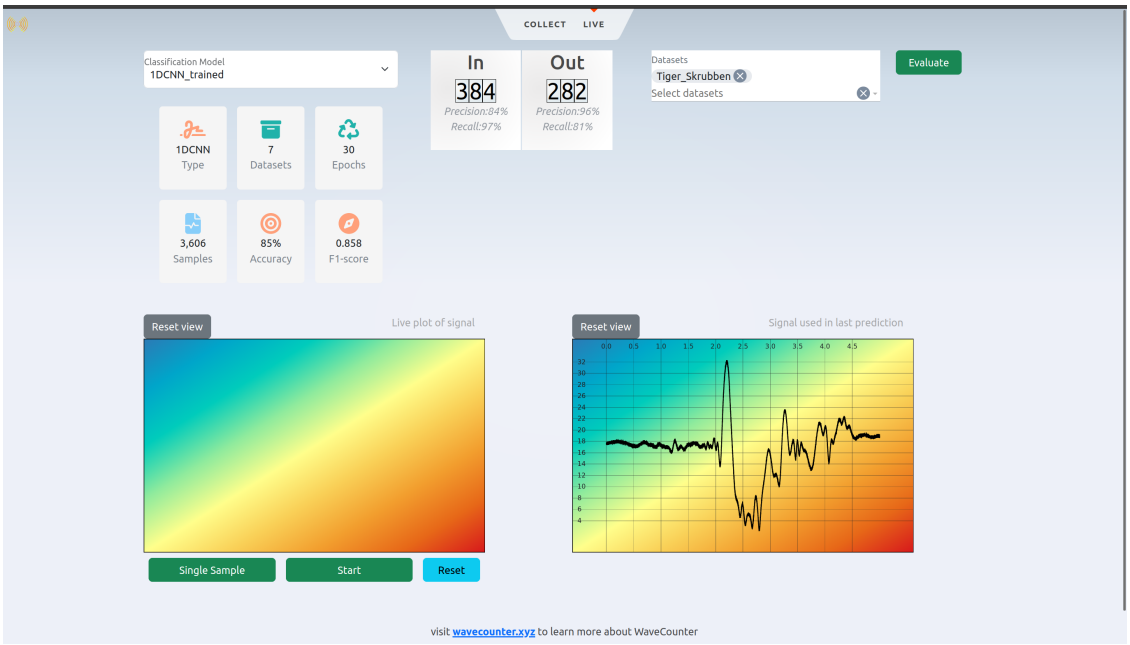

Figure 6: A view of the Live-page in the user interface.

5 AVAILABLE MODELS

The WaveCounter has three different machine learning models that you can use for classification. These models are all CNN-models using different amount of layers and different amount of epochs during training. More models might be available later, so be sure to keep a close eye at `https://wavecounter.xyz/` to always have the newest models available for your WaveCounter.

If you want to have a customized model for your specific environment, please send us your collected dataset and we will make it happen! If you wonder how to collect your own datasets, please see section 4.1.3.

Depending on the environment and model choice the result might vary. We therefore recommend you to try all available models too see which performs better in your environment.

5.1 Convolutional Neural Network (CNN)

The CNN assumes a correlation between neighboring elements in the data. This is useful when the data is a time series, images, or any similar data. In the case of CSI data, which is being estimated from the recieved signals from the ADALM-PLUTO devices, one can apply a CNN on spectrograms. The network trains filters and performs convolution in every layer. The CNN is ended with a fully connected layer to perform the final prediction.

6 LIMITATIONS TO BE AWARE OF

For the system to perform as expected while using any of the default models there are a number of things that the user must have in mind, these will be listed here in this section.

- Pass through the doorway in walking speed (1 - 2 m/s), or else the system might not detect the passage.
- When passing, start walking a few meters from the door and walk until you have passed the door with a margin of some meters.
- Pass one person at a time. The system is trained to detect **one** person at a time, so if two or more people pass simultaneously it will most likely only detect one passage and have a high risk of missclassifying this passage.
- The system is designed to detect people walking normally, do not expect the system to correctly classify a person jumping or doing something fuzzy while passing trough the door.

7 TROUBLESHOOTING

If your WaveCounter malfunctions, starts to show wierd signals or missclassifies way more than the chosen model should, there are a number of things that you can do before contacting your WaveCounter representative.

1. Analyse the received signal. In the user interface you will see a real time plot of the received signal. If the amplitude of this signal does not change drastically when someone is passing trough the doorway, then something is either wrong with the setup, or with the hardware. Look to see if you can identify any obvious issue with the setup, else try resolving the issue with the next steps in troubleshooting.
2. Unplug your ADALM-PLUTO devices from your computer and wait a few minutes before plugging them back in. Once they are connected to your computer, reload your browser and try again.
3. Open your terminal and run
    a) make stop
    b) make build

c) make init

d) make run

Then reload your browser.

4. Try using another model! In some environments the models might tend to perform differently from one another. So try using different models for classification and see if the problem persists.
5. Try using the "Validation" functionality in the user interface with an already recorded dataset to if the problem lies in the model. If this works well, then the problem is somewhere at the hardware part of things.

If the issue persist after trying the above steps for troubleshooting, please contact your WaveCounter representative for support.