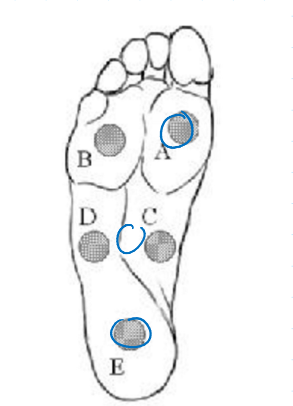
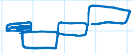
Group Work

Mittwoch, 29. Januar 2025 14:54

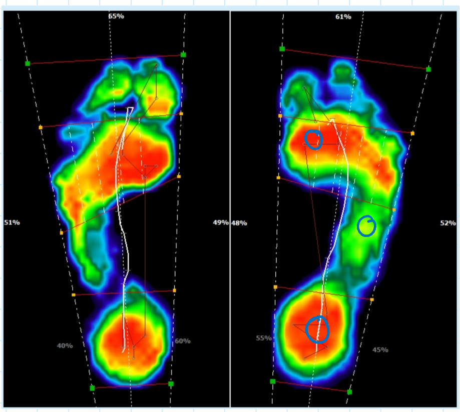
Step counting

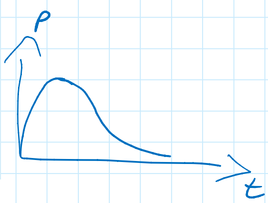


IMU located at the ankle

Walking	detected by cyclic pressure changes on the heel and toe IMU for better accuracy; captures acceleration, rotation and weight changes
Running	higher impact forces + faster cadence, no contact with ground for a little time span
climbing stairs	 IMU ↗
standing	constant level of pressure
sitting	only a little pressure on the socks
Rope jumping	sudden pressure release, pressure peaks, sudden pressure change
Foot tapping	for music, all the time pressure at the back, when tapping it comes to the front
Squating	pressure increases when moving downwards decreases when moving upwards

https://bewegungstherapie-hannover.de/fussdruckmessung-und-ganganalyse/





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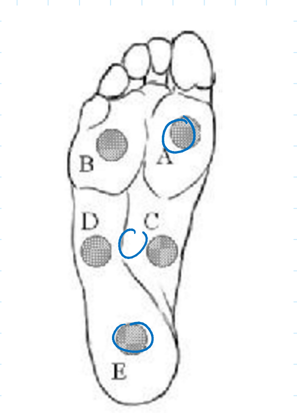
STEP 1

Step counting

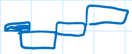


IMU located at the ankle

• Functional Requirements

Walking — detected by cyclic pressure changes on the heel and toe
IMU for better accuracy; captures acceleration, rotation and weight changes

Running — higher impact forces + faster cadence, no contact with ground for a little time span

climbing stairs  IMU ↗ (Asymmetrical pressure shifts on the forefoot)
IMU can differentiate → ascending (more toe pressure) → descending (more heel pressure)

standing — constant level of pressure

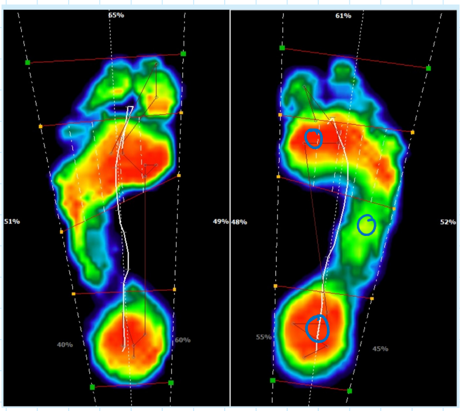
sitting — only a little pressure on the socks (IMU should detect zero acceleration)

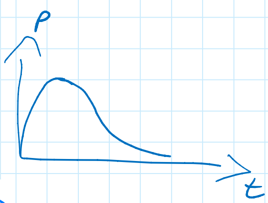
Rope jumping — sudden pressure release, pressure peaks, sudden pressure change

Foot tapping — for music, all the time pressure at the back, when tapping it comes to the front

Squating — pressure increases when moving downwards, decreases when moving upwards

https://bewegungstherapie-hannover.de/fussdruckmessung-und-ganganalyse/





New Activities

/ (1) • one foot raised from the ground → The pressure that we detected on the graphs should be almost close to zero 

/ (2) • both foot resting on the ground → The pressure that we detected on the graphs should be stable, with only small changes 

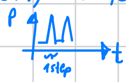
/ (3) • one foot resting on the ground and one foot is raised from the ground → The pressure in the foot that is resting on the ground should be higher than the second case (2) 

/ (4) Sitting position → The pressure should detect little pressure on the foot 

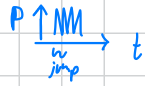
/ (5) toe tapping → The pressure should detect more pressure on the front part of the foot 

/ (6) heel tapping → The pressure should detect more pressure on the back part of the foot 

(7) step recognition → Every time the pressure change suddenly from a value close to zero and their peak value and then come back to a value close to zero one step should be counted



(8) jumping Similar to step recognition, but I will expect that the pressure detected change suddenly from a low value to a high value



(9) walking →

Sakkopola or Design Factory per IMU

Why IMU?

- For detecting non-contact movements (mid-air foot rotations are hard to mesaure with pressure sensor alone)

- To compare data collected with and without an IMU
  (accuracy of activity classification, differences in step counting precision)

Non-Functional Requirements

(Use the needle to sew, and to do the interconnection)

- Werability → That is why we change techique from lamination to stitching.
  - Comfort → Sock should feel natural and comfortable to wear for extended periods
  - Flexibility → Materal should be strechable and not restrict foot movement
  - Weight → Embedded sensors and electronics shorld be lightweight to avoid discomfort

- Cost Efficiency
  - Affordable Materials → Low-cost available conductive textiles and sensors.
  - Minimal Electronic Components → Optimize the number of sensors
  - Energy Efficiency → Low-power components to extend battery life and reduce costs

- Durability → Resistant to wear and tear

- Reliability → Sock should endure frequent use without sensor degradation

- Aesthetics → Sensors and electronics should be embedded without making the sock look bulky

Sensor Selection

STEP 2

Two types of model proposed:

- 3 pressure sensors for each foot + IMU sensor (if required)

or

- 5 pressure sensors for each foot + IMU sensor

ⓐ Pressure Sensor

Force-Sensitive resistor (FSRs)

or

Conductive fabric pressure sensors

- To mesaure pressure distribution

Placement: (heel, arch, ball of foots, toe)

(b) IMU → 6-axis (accelerometer + gyroscope)

Detects dynamic movements like stair climbing, jumping

Placement: on the ankle / top of the foot (minimize discomfort)

STEP 3

Design

- Arudino Uno
- Pressure Sensors (FSRs or Textile Sensors)
  ↳ Connected using conductive threads to avoid bulky wires. (Optional Multiplexed to reduce wiring complexity)
- IMU (Accelerometer + Gyroscope)
  ↳ Mounted near the ankle for better motion tracking
- Stretch Sensors (Optional)
  ↳ Placed on the top of the foot or Achilles tendon. Uses an analog input pin for foot flexion detection

Integration of all electronics into a small ankle band to avoid discomfort

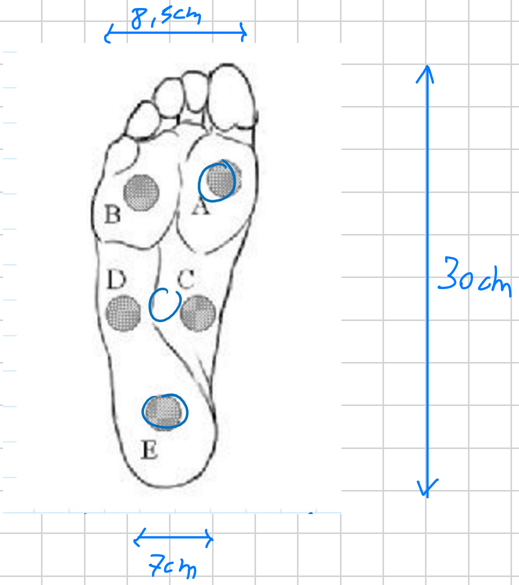
User Testing Approach for Wearability

- Have 5-10 users wear the prototype and perform different activities.
- Collect feedback on comfort, fit and movement restrictions.
- Ask users to rate ease of wearing/removal and overall comfort on a 1-5 scale.

3 yarns to 3 different analog pin

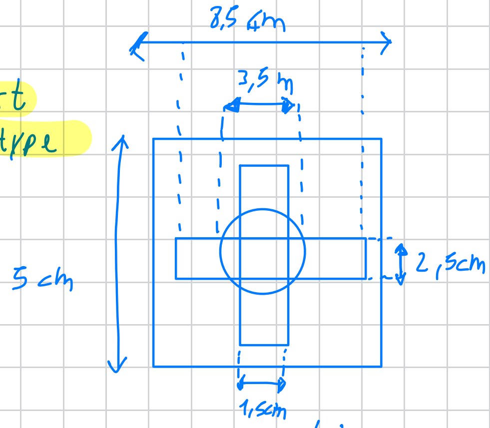
How we want to design the pressure sensors?

- We have to laminate 3 pressure sensors.
  - Toe → Pressure sensors with 5 layers
  - Midfoot → Pressure sensors with 3 layers
  - Heel → Pressure sensors with 5 layers

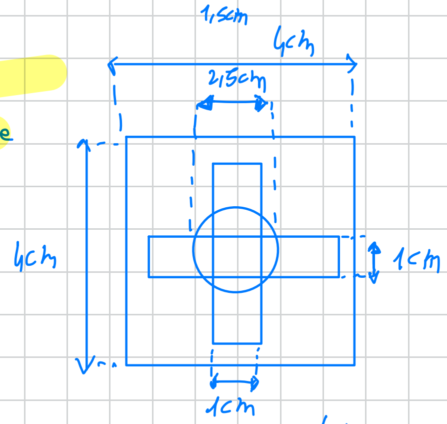


If there is a higher resistance, the saturation point will be reach later (more pressure/weight can be put on)

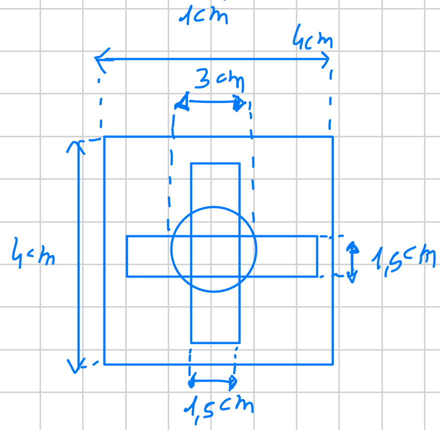
- First Prototype



- Second Prototype



- Third Prototype



- Stitched Sensors (Best for Low-Cost Prototyping)

Recommended for early-stage prototypes.

Advantages in using this technique instead of lamination are:

- Easy to implement → simple sewing techniques in order to integrate conductive threads or small sensors
- Low-cost → Ideal for quick prototyping without expensive knitting machines
- Flexible sensor placement → Sensors can be easily adjusted by restiching

(RESISTANCE)	(VALUE OF PRESSURE) MIN VALUE PRESSURE	MAX VALUE PRESSURE	
• 100 Ω	180	605	✓
• 56 Ω	272	520	✓
• 82 Ω	262	610	✓
• 330 Ω	502	878	✗
• 10 Ω	22	105	✗
• 10 K	Small variation, we reach maximum value very fast because the voltage goes only on the larger resister		✗
• 150 Ω	138	730	✓

Resistance of our pressure sensor is around 800 Ω.

STEP 4

First we create different prototypes of different sizes and dimension, using the lamination techinque in order to obtain different pressure sensor.

Moreover, it was necessary for us to change resistance because in the beginning we we a resistance of order of KΩ but the pressure sensor that we create have a lower internal resistance, generating a small range of variation when pressing the sensor (NOT GOOD!!).

After testing different resistors as we can see from the table above we decided to use a resistor of 82 Ω, in our initial set up to collect variation in pressure when we push one pressure sensor, using Arduino and Processing.

Overview of the Prototype

The prototype is designed to collect foot movement using stitched pressure sensor and an IMU. Data transmitted to a computer for further analysis.

Hardware Components

○ Sensors

- Pressure Sensor (Force Sensitive Resistors - FSRs or Textile-Based Sensors)
  ↳ For detecting foot-ground contact
- IMU (Accelerometer + Gyroscope)
  ↳ For tracking motion and orientation

○ Microcontroller
- Arduino Uno

○ Circuit and Wiring
- Flexible conductive traces stitched onto fabric

Assembly and Stitched Process

○ Sensor Placement and Attachment
- Pressure sensors stitched under the heel, instep and ball areas.
- IMU sensor attached near the ankle

○ Wiring and Circuit Connection
- Pressure sensors connected to Arduino's analog inputs with pull-down resistors
- IMU connected via I2C (SDA, SCL pins)

○ Integration with the Insole
- Sensors and conductive pathways stitched between insole fabric layers

Software Development (Arduino IDE)

- Use analogRead() for pressure sensors
- Use I2C Communication for IMU data

○ Data Transmission to Computer
- USB Serial Communication: Monitor real-time data in the Arduino Serial Monitor

○ Data Logging and Visualization
- We use Python (Matplotlib, Pandas), and Processing to visulize sensor readings

- Store the data in a csv file on Excel through using VSCode

STEP 5

- Data Collection Setup

- We will recruit at least 2-5 participants, possibly from different ages, gendar and weight.

- Experimental Procedure (Not defined yet)

- Data Labeling

- We have to use manual annotation to match sensor readings to the correct corresponding activity.
  - ↳ Define a threshold for some gesture/activities that we want to detect and they must be the same for different people.

TESTING

Show the data that we collected in a graphs. CSV file already created