



Universität Hamburg

DER FORSCHUNG | DER LEHRE | DER BILDUNG

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Bachelor Thesis

Force-Sensing Book

Contents

- 1 Introduction
- 2 Design
- 3 Software
- 4 Experiments
- 5 Evaluation
- 6 Conclusion

Contents

1 Introduction

2 Design

3 Software

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1 Introduction

1.1 Overview

1.1 Contributions

1.1 Overview

- Robotics a broad topic in research and industry
- Take over tasks and simplify work of humans
- Robotics in many industries e.g. metal industry, car manufacturing
- Precision and force precisely determined in movements
- industry 4.0

1.1 Overview

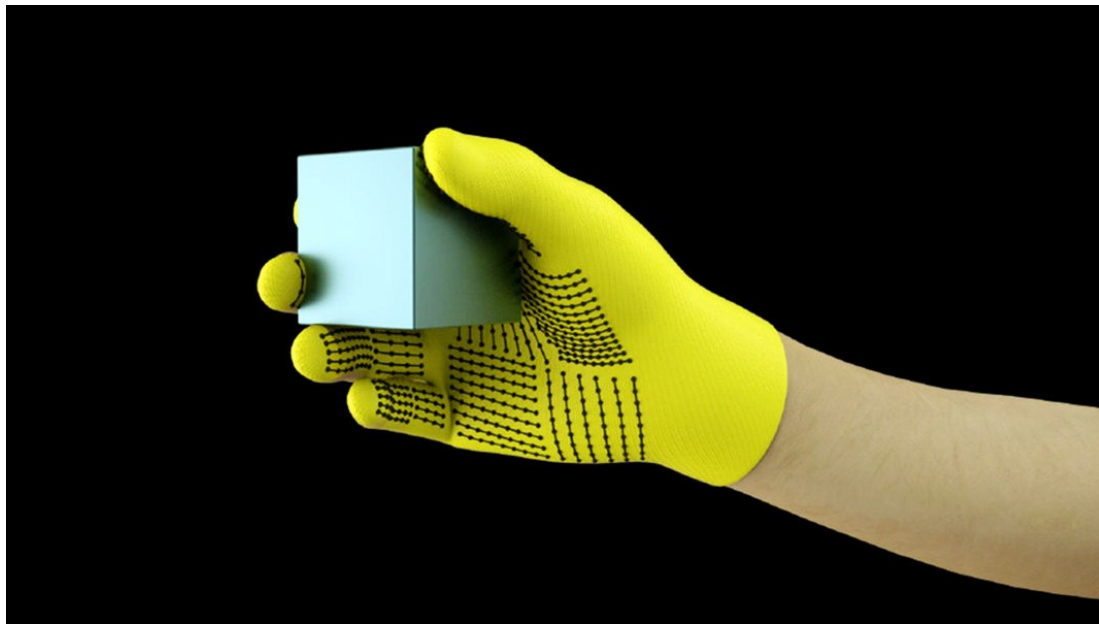
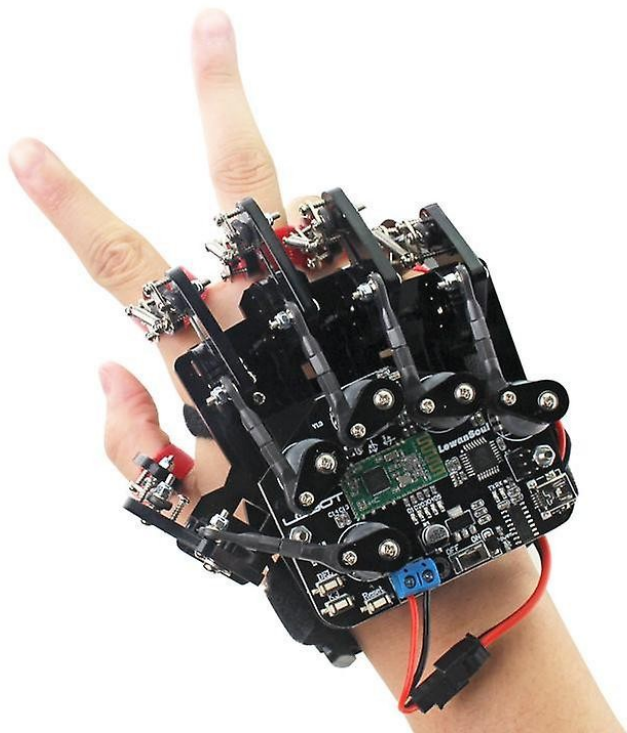


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- Robotics a broad topic in research and industry
- Take over tasks and simplify work of humans
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- Precision and force precisely determined in movements
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1.1 Overview

- Another Topic: Getting Closer to the human
- Research for applications e.g. in medicine
- realization of hand and fingers still pose various problems
- Big problem: force and tactile perception of fingertips
- measured with sensors attached to the fingers: Gloves
- might limit and consequently attenuating tactical perception



1.1 Overview

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1.2 Contribution

- Idea to not place sensors on hands but the manipulated object
- to answer core question whether more accurate measurements results can be achieved
- design and create sensory object in the form of book
- task of book to record certain manipulation tasks

1.2 Contributions – Manipulation tasks:

- Pushing book across table
- Pulling book from shelf between other books
- Picking up book from table
- Re-grasping book with both hands
- opening book and turning page

1.2 Contributions

Force Sensing book:

- Wifi-Microcontroller Arduino Nano IOT with an IMU
 - 5x HX711 Modules
 - Power bank
-
- Book sends data to host computer
 - Data analysed on host computer

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2 Design

2.1 Chosen Hardware

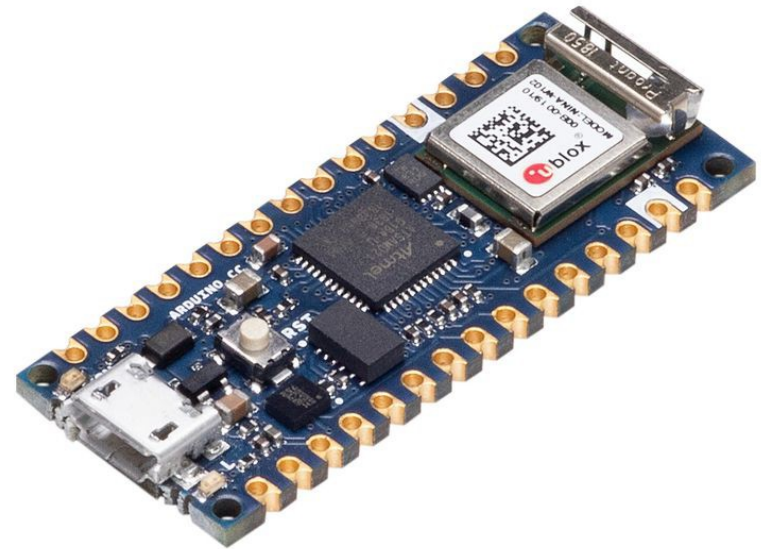
2.2 Designing the Book

2.1 Chosen Hardware

Arduino Nano 33 IOT

- microcontroller
- Inertial measurement unit
- WiFi
- 45mm x 18mm

- many features
- small and light



2.1 Chosen Hardware

Power Bank Logilink PA0207

- Power Bank
- 3000mAh
- 5V
- USB
- 86mm x 61mm x 13.8mm

→ largest component

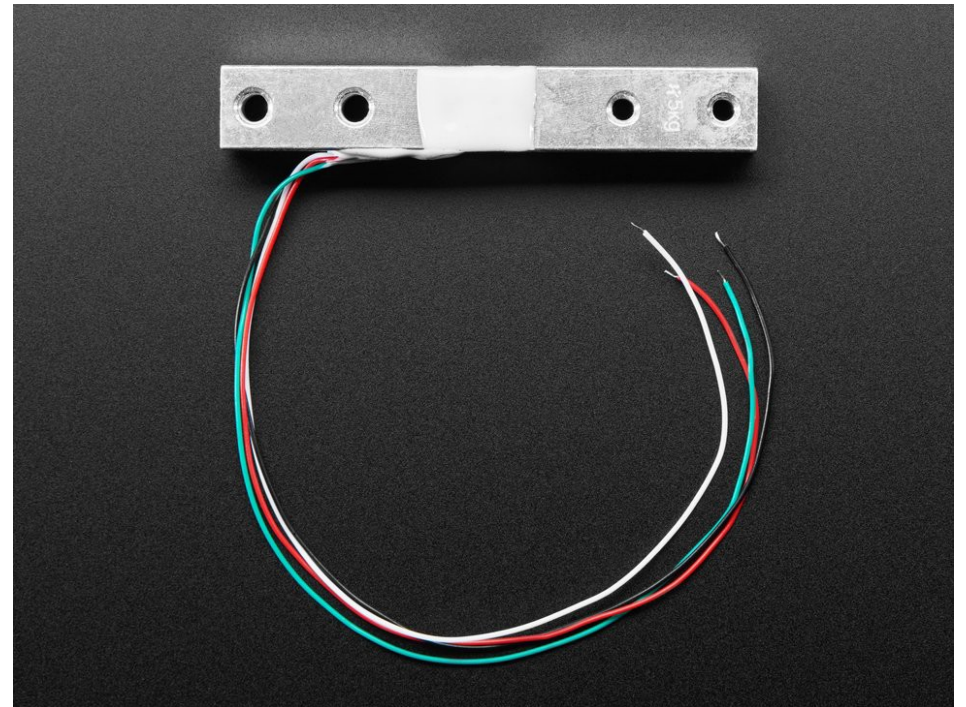


2.1 Chosen Hardware

5x Strain-Gauge Load Cells

- 5kg max
- 80mm x 17.5mm x 17.5mm
- Strain-Gauge in the center measures deformations

- 4x on each corner
- 1x for tilting the book



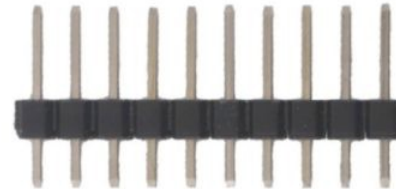
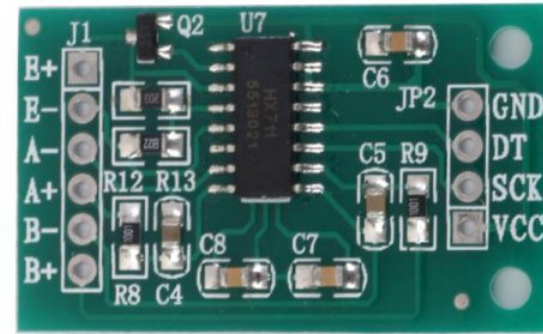
2.1 Chosen Hardware

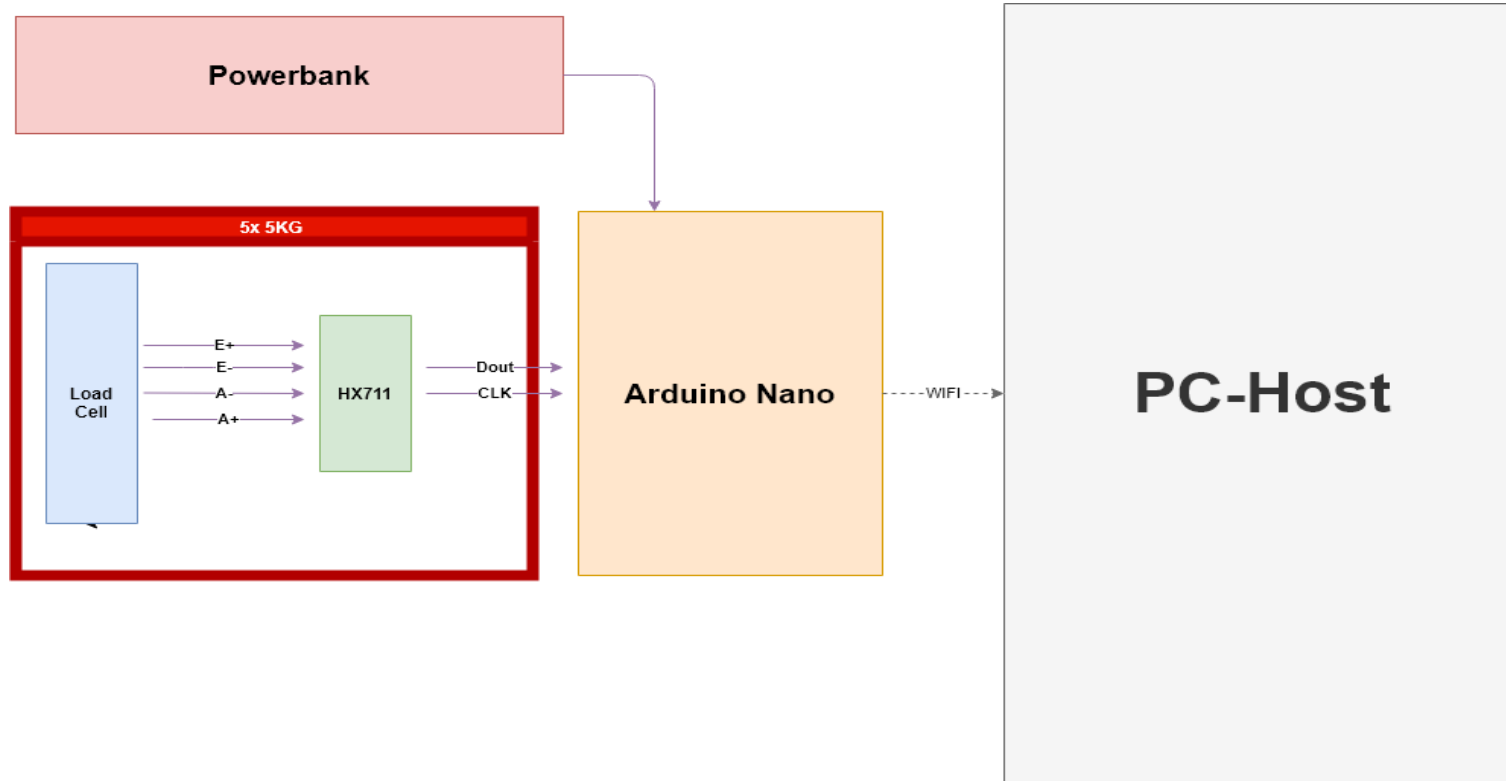
5x HX711 24 amplifier module

- converts analog signals to digital signals

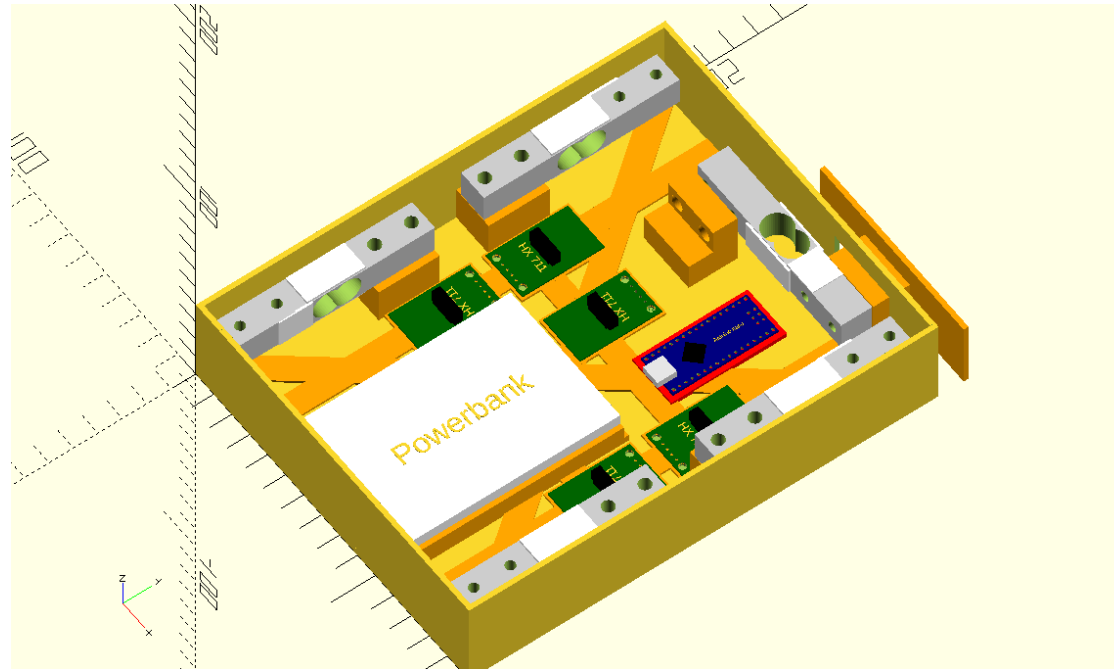
- 33.6mm x 20.5mm

- Sensor preparation for higher frequency





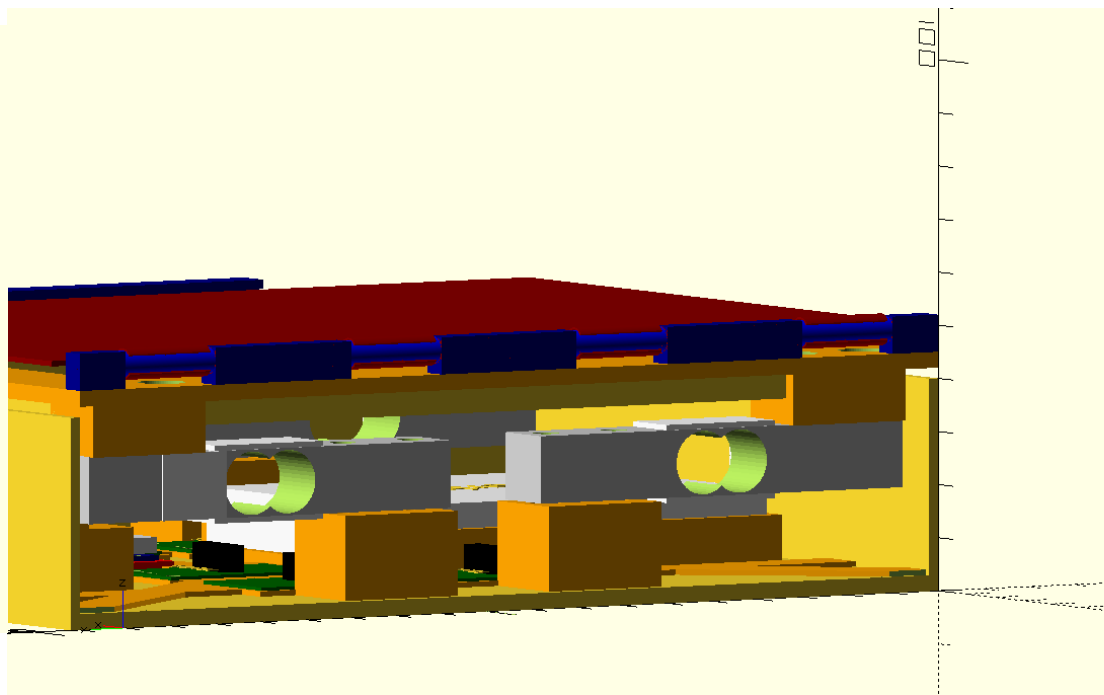
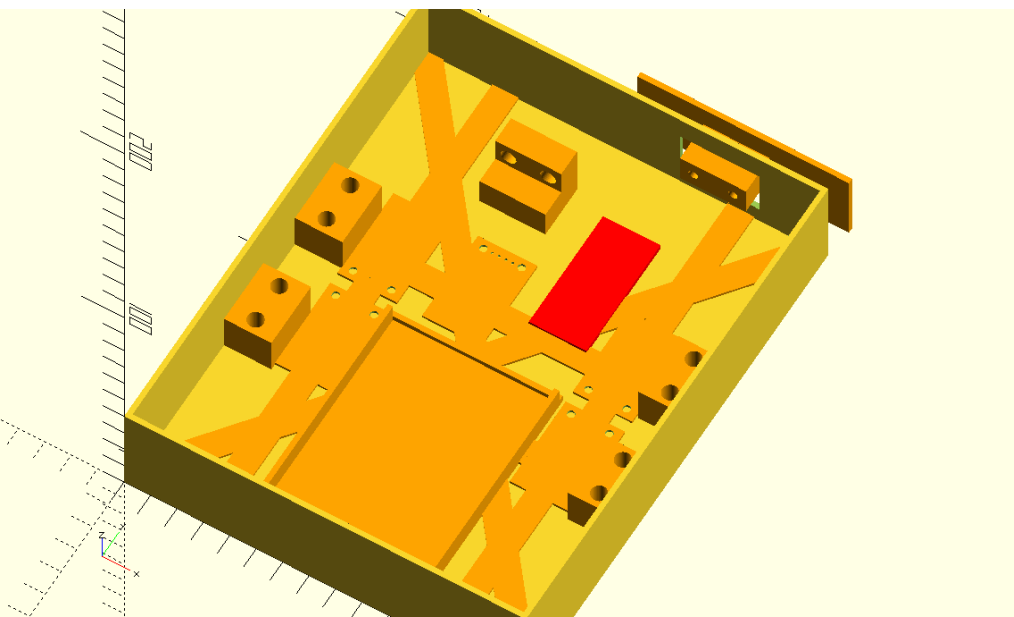
2.2 Designing the Book



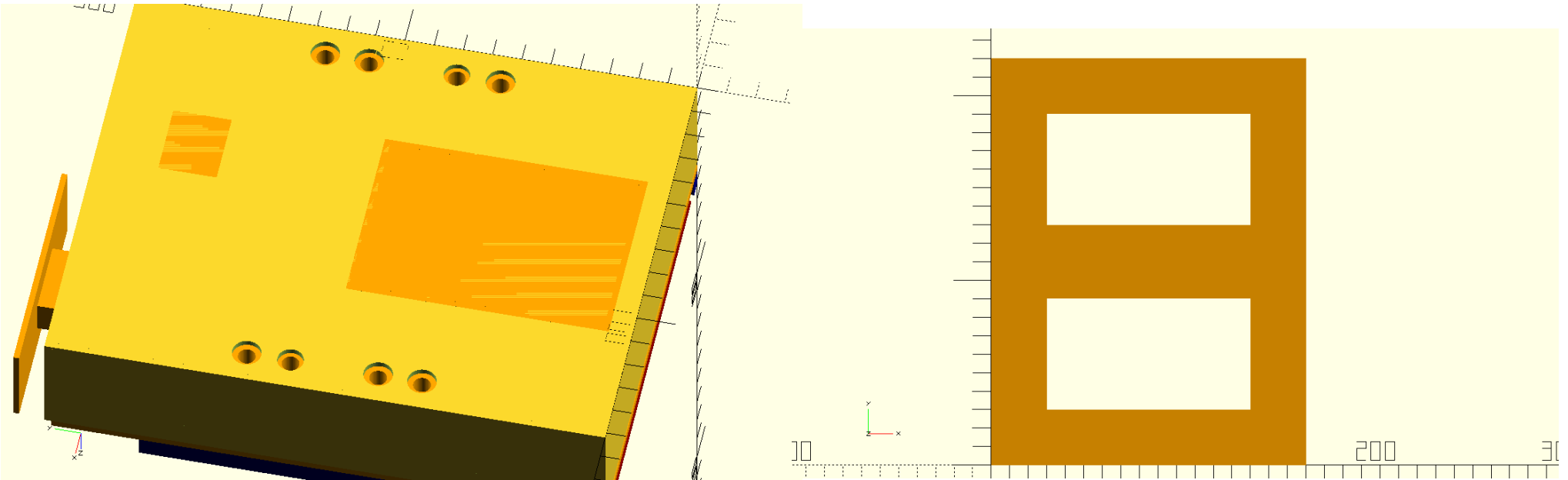
2.2 Designing the Book

- 190mm x 150mm and 2mm thick surfaces
- Hardware components placed on the bottom, inside
- extra struts to support holding hardware components
- Only connection between top and bottom through Sensors
- 4 sensors, 1 on each corner
 - stability, reducing bending possibility
 - calculate surface-position of force

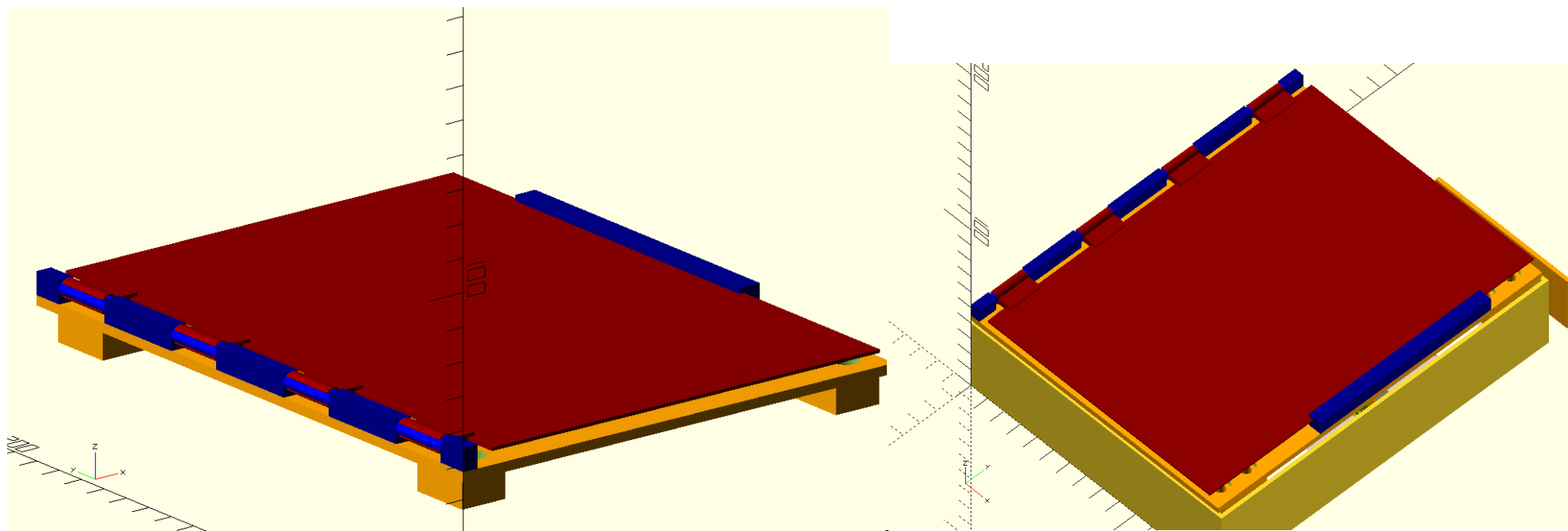
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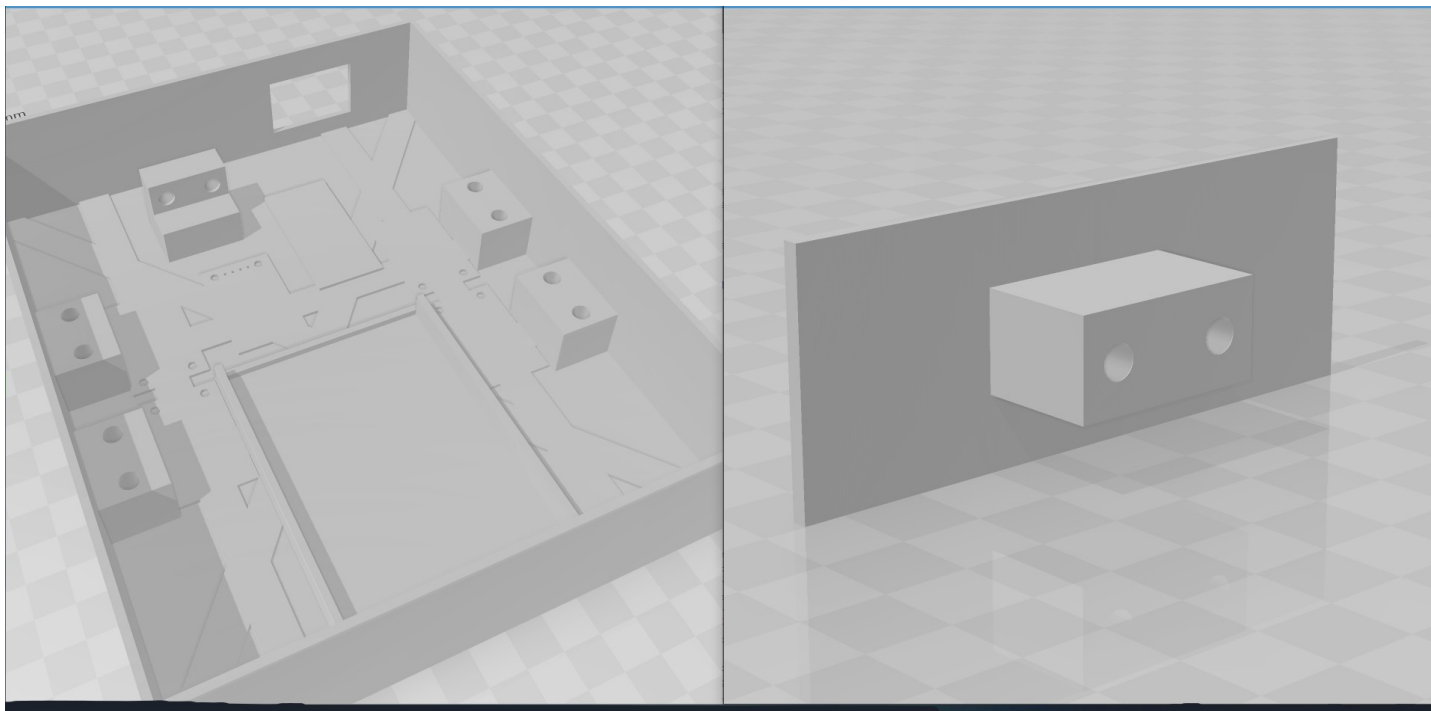
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2.2 Designing the Book



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3 Software

3.1 Arduino Software

3.2 Host Computer Software

3.3 Communication

3.1 Arduino Software

- Designed for embedded systems
- after a setup enters an endless loop
- initializes all sensors
- reads sensor measurements and sends them to host computer

3.2 Host Computer Software

- endless loop
 - receives data from Arduino and saves it temporary
 - possible to receive commands and start recording experiments
 - can save data for future investigation
-
- with another script: Plot Data

3.3 Communication

User Datagram Protocol (UDP)

- minimal and connectionless network protocol
- send and receive message packages
- low latency
- more suitable choice than TCP

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4 Experiments

4.1 Pushing book across table

4.2 Pulling book from shelf between other books

4.3 Picking up book from table

4.4 Re-grasping book with both hands

~~4.5 opening book and turning page~~

4 Experiments

1. book resets
 2. set offsets to zero-point
 3. Calibration with cup
 4. Start Experiment
 5. Stopp Experiment and save received data
 6. Plot and analyse data afterwards
- Bad enviroment: cameras are missing

5 Evaluation

5.1 Design Evaluation

5.2 Old Book Data Evaluation

5.3 New Book Data Evaluation

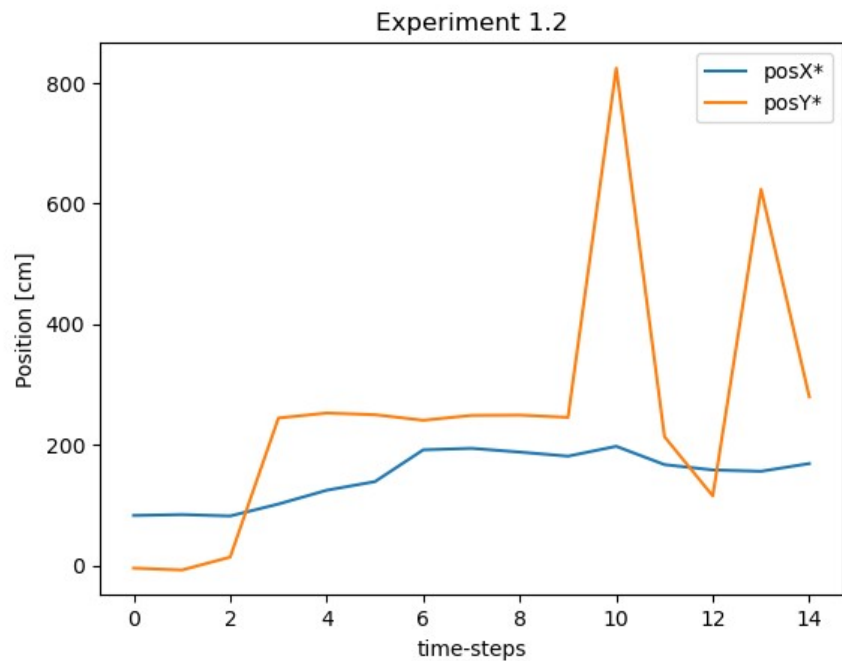
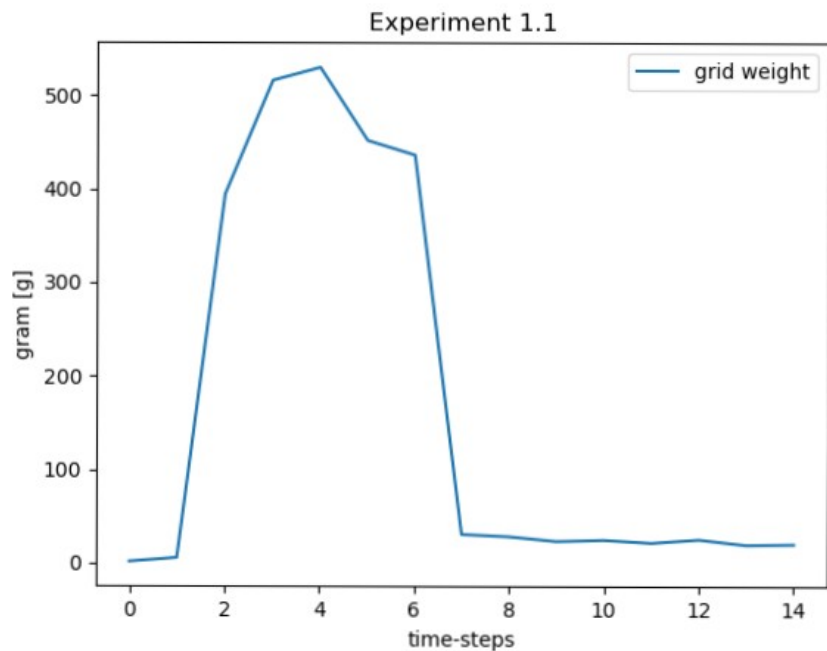
5.1 Design Evaluation

- drillings not matching actual load cells
- grid need to be thicker → not stable enough and can bend
- cover page cannot be clipped into grid
- Power Bank and Arduino too close to each other
- object loses book-like appearance with the grid and without cover page

5.2 Old Book Data Evaluation

- tilt sensor is not working
- the top-left sensor does not read reliable data
- Cup can be measured with an 5% uncertainty
- catastrophic frequency with 1.3s per arduino-loop
- data is not reliable and no further or reasonable conclusion can be made
- Bad environment: cameras are missing

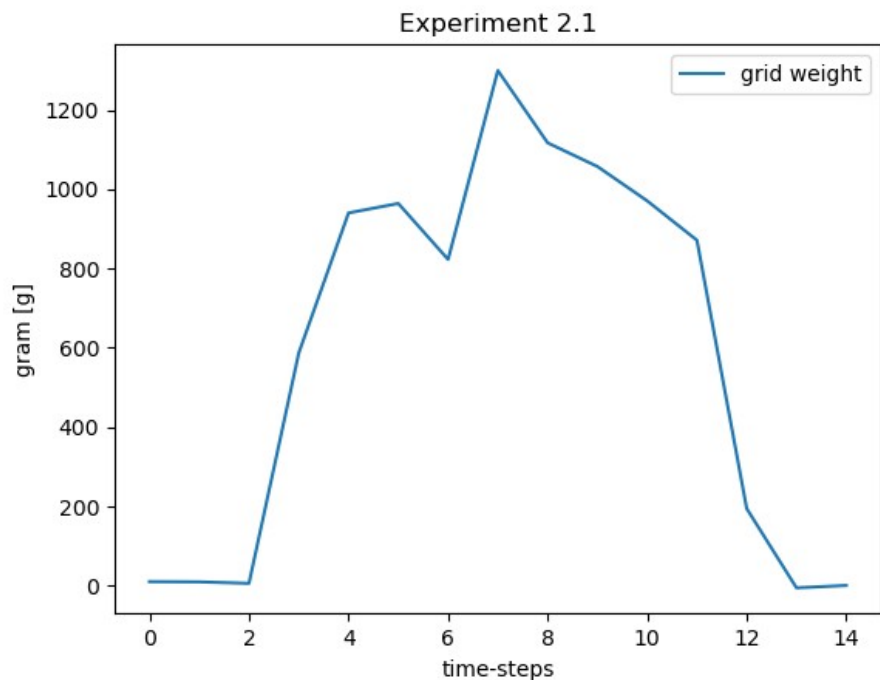
5.2 Pushing book across table



5.2 Pushing book across table



5.2 Picking up a book from a table



5.2 Evaluation old Book

- Failure
 - Core Question cannot be answered
 - wiring and therefore Short circuits probably the problem
 - need to rewire and redo experiments
- new Book

5.3 New Book Data Evaluation

- grid thicker
- tilt sensor works
- higher frequency
- could not do experiments in time, host computer does not retrieve data
- one sensor still does not work reliable
- not accurate as a glove

6 Conclusion

- even the smallest and simplest seeming aspects can be complicated
- Sensory gloves are established in science and research continuous
- Book is still not powerful enough to keep up with gloves → cannot answer Core Question directly
- influence of reduced sense of touch has to be minor

Figures

[1] <https://cigen-rpa.medium.com/the-impact-of-robotic-process-automation-on-the-automotive-industry-6a0eabaf9ee1>

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[3] https://www.fruugo.de/wearable-mechanical-gloves-sense-and-robot-control/p-51469806-103589132?language=en&ac=croud&gclid=Cj0KCQiA2NaNBhDvARIsAEw55hiX9bEXoW89QQ_FzbUE0kVZFsN4TwlEQ6duuCa0PfBmJSteLaHn1bgaAp-DEALw_wcB

[4] <https://singularityhub.com/2019/06/03/these-10-sensor-packed-gloves-could-give-robots-a-sense-of-touch/>

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Thank you very much!