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| Disassembly Project |  |
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## **Preface**

This report is about the disassembly project. This project endeavours to enhance the disassembly 1 identification and inspection stages. Previous efforts have primarily refined the sorting system utilizing a robotic arm. However, the current focus is to augment product identification and inspection capabilities. The primary objective is to develop a prototype capable of swiftly and accurately identifying products with minimal training requirements. Before proceeding with the prototype development, it is imperative to conduct comprehensive research on the available technologies and methodologies pertinent to this objective. Needs to be fixed not priority

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## **Version management**

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## **Summary**

## **Glossary**

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| **Special words** | **Declaration** |
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## **Introduction**

## **The company**

### 2.1 About Fontys Innovation Lab Hight Tech Embedded Systems (HTES)

The HTES research group conducts applied research on systems in which robots and humans work together and use data and knowledge about their environment to act. We look at systems in the following four application areas:

⦁ Smart Industry - digitalisation of the manufacturing industry - data, work processes,

robotics.

⦁ Robotlab (Big Chemistry) - digitisation of chemistry - data, AI, robotics.

⦁ Smart Disassembly - digitalisation of de-assembly in return flows of products.

⦁ Air quality perception (AQE) - air quality perception for the living environment – measuring

with IoT, citizen science.

The research group looks at this from a technical ICT perspective, focusing on the use of modelling to determine and improve the architecture and the way systems are integrated. Research on modelling focuses on creating digital twins. Various technologies are used for this purpose, such as machine learning, Internet of Things, asset administration shell, digital product passport, intelligent agents. They do this with companies that are partnered with Fontys ICT and other innovations labs in the Netherlands.

## **The assignment**

### Context

Smart disassembly is a project running at the HTES research group. Disassembly is about separating products, to get a product decomposed in its parts. It is a phase when remanufacturing, refurbishing or recycling a product.

Problems that arise with disassembly is for example the problem of how every product needs to be disassembled in a different way. A product might be disassembled easily when parts are just clicked together. Sometimes the disassembly is more difficult when parts are glued together, and also when thinking about how to determine and guarantee the status of the product components can be difficult. These problems I had to tackle in my assignment.

### Cause of the assignment

The manufacturing industry faces a pressing challenge: balancing economic growth with environmental responsibility. Our reliance on raw materials and traditional manufacturing processes contributes significantly to greenhouse gas emissions and resource depletion.

This is where the Disassembly Project comes in. By focusing on disassembly as a core strategy, we aim to create a more sustainable future for the Brainport region's manufacturing sector. Disassembly unlocks several key benefits:

* Reduced reliance on critical raw materials:   
  By efficiently disassembling products, we can reuse valuable components, lessening the demand for raw materials. This helps conserve finite resources and protects the environment.
* Lower carbon footprint:   
  Manufacturing from scratch is energy-intensive. Disassembly allows for remanufacturing, refurbishing, and recycling, all of which require less energy compared to traditional production methods. This translates to a significant reduction in greenhouse gas emissions.
* Improved resource management:   
  Disassembly promotes a circular economy, where products have a longer lifespan and resources are kept in use for as long as possible. This minimizes waste generation and promotes responsible resource management.

The HTES research group recognized that companies need practical tools to imrpove the disassembly process. The Disassembly Project, with its focus on creating a more automatic disassembly line, will provide manufacturers with the knowledge and resources required to achieve a more sustainable production model.

### Goals of the assignement

The project endeavours to enhance the disassembly program by advancing the classification, identification and inspection stages (circled in figure…. ).Afbeelding met tekst, schermopname, Lettertype, Rechthoek

Automatisch gegenereerde beschrijving

Me and the company mentor set the following goals:

1. Find and test time and resource efficient ways to identify products.
2. Find and test efficient ways to inspect a product.
3. Make a demo to show my findings.

### Realisation

### Planning of the assigntment

For the planning I used a sprint system of 2 weeks. Every 2 weeks I talked with my company supervisor what his wishes where for the next 2 weeks while I presented my work from the previous 2 weeks. I also saw him every Wednesday to talk about technical stuff and if I needed help/advise.

## **The research**

### Research questions

**Introduction**

The primary focus of this research is to determine the most efficient methods for detecting products. This involves investigating both the training of vision models and the performance of the models themselves. Some key aspects of the research include identifying the most effective vision models and algorithms, as well as determining the optimal 3D scanner for the purpose of training vision models.

**Research questions**

* **Main Question:** What computer vision approach can be used to properly detect product parts - in the context of product disassembly?
* **Sub-question 0:** What are the existing approaches in the industry, and why have these been chosen?
* **Sub-question 1:** How best to set up/focus the computer vision approach to make 'learning' a product as easy as possible (little resources, effort and time saving)?
* **Sub-question 2:** How can we make it easier for computer vision methods to detect products?
* **Sub-question 3:** How can we integrate identification data with manipulation tasks (robotic or human) and later tasks in the disassembly line?

### Realisation and results of the research

During my research, I started by exploring how companies and the internet detect products. I discovered that while there are various fast ways to detect products, achieving accurate results requires significant setup time per product. This is a common struggle for companies as well. For instance, companies like Affix use product images to train models, but since they don't have a lot of products, this isn't a major challenge for them.

However, companies like AM-Flow, which deal with a continuous flow of products, face a bigger problem. Fortunately, their products are always 3D printed, which means they have digital models and predictable shapes. Though their approach doesn't align perfectly with my project, it is still interesting. They train models using the 3D models of the products and they mainly focus on the shape of the models. They also shared the difficulties they encountered, such as shadows and variations in shape due to different viewing angles.

To overcome these challenges, AM-Flow employs four cameras to capture all four sides of the product, and they use large flashes of light during image capture to eliminate shadows. This information provided valuable insights for my project.

Additionally, I conducted a comparison between the Artec 3D scanner and the iPhone 15 Max 3D scanner. The results showed that the Artec scanner outperformed the iPhone 15 Max in terms of quality, making the price difference and ease of use insignificant factors.

**More to come first need to finish the last part of the research**

## **The product**

### The previous product

Prior to my involvement in this project, there was another person who primarily focused on the sorting aspect of the disassembly line. Their contribution involved creating a system that could identify cans of cola and utilize a robot arm to pick them up. However, their method of achieving this task was not fully automated. They captured numerous pictures of the cans and trained a YOLO model (a computer vision system) using these images. Then through a 2-lensed camera, they were able to determine the distance of the object and pick it up and sort it.

### Designs

I made multiple flowcharts for the project to get a good overview for my company mentors.

The flowchart got updated a few times and even separated to make it more clear so I will talk about how it happened. At first the flowchart was to focused on how the vision system worked but not how I saw the whole system. Even though I was not going to make the whole system for the identification but mainly the vision part of it because else it was out of scope. But because people might work on top of what I have made I needed to make sure people what my vision was and what I thought what would be smart to add to it. They also requested to split the way to train a vision model from the flowchart because it was really confusing.

I created multiple flowcharts to provide my company mentors with a comprehensive overview of the project. The flowcharts underwent several updates and were eventually separated to enhance clarity. Initially, the focus of the flowchart was primarily on the functioning of the vision system, neglecting the larger system as a whole. Although my role was mainly around the vision part of the identification system, it was necessary to show my overall vision and suggest valuable additions for others who would be working on the project. My company mentor has also requested that we split the vision training part in order to simplify it.

**Explanation for the first flowchart (see appendix…)**

The first flowchart outlines the identification and classification process for the disassembly line. It begins by checking if the product can be detected quickly and easily, using methods such as weight and shape recognition. If this initial check is successful, the product is identified and classified accordingly.

If the initial check is not successful, the flowchart proceeds to scanning the barcode or QR code on the product. If This successfully identify the product, it is identified and classified accordingly.

If none of the above methods are able to detect the product, the flowchart moves on to the vision model. The vision model is considered the most challenging method as it requires more complex analysis and processing. If the vision model successfully detects the product, it is classified and identified accordingly.

However, if the vision model fails to detect the product, the flowchart proceeds to combine the available data to see if a collective analysis can lead to successful identification and classification.

Overall, the flowchart presents a systematic approach to identifying and classifying products in the disassembly line, starting with the simplest and most efficient methods before moving on to more complex and resource-intensive techniques.

**Second flowchart (see appendix…..)**

The second flowchart shows how the vision model would be trained. The vision model needs to be trained using a 3D model. If this already exists you can skip the 3D scanning part but if there is no model it needs to be made through 3D scanning the product. After you have a complete 3D model it needs to be imported to blender and renderd so a animation can be made of it. You can save the animation instead of a video you can save it for every frame in a jpg file. If YOLO will be used or a similar kind of vision model the corners of the object needs to be saved to make a bounding box. So it smart this always will be done. After you saved the animation you will have thousands of pictures of the 3D model and you can create a dataset from that but this differs per vision model so I didn’t include this in the flowchart.

The second flowchart outlines the training process for the vision model. The initial step involves training the model using a 3D model. If a 3D model already exists, the 3D scanning step can be skipped. However, if there is no existing model, it needs to be created through 3D scanning of the product. Once you have a complete 3D model, it should be imported into Blender for rendering an animation. Instead of generating a video output, the animation can be saved as individual frames in jpg format. In the case of using YOLO or a similar vision model, the corners of the object must be saved to create a bounding box. It is recommended to always include this step for better accuracy. After saving the animation, you will have thousands of pictures of the 3D model, which can be used to create a dataset. However, the specific process for creating the dataset may vary depending on the type of vision model being used, so this step is not included in the flowchart.

### Realisation

### Finalproduct

## **Conclusion and recomondations**

## **Evaluation**

## **References**

## **Appendix 1: Flowchart 1**

A diagram of a diagram

Description automatically generated with medium confidence

## **Appendix 2: Flowchart 2**

A black screen with white lines

Description automatically generated