COLOR SORTER

SMJE 4263 COMPUTER INTEGRATED MANUFACTURING GROUP PROJECT

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Abstract

This project develops and implements a colour sorter for CIMS. Using image and optical sensors, the colour sorter sorts things by colour. It sorts items into bins based on pre-defined criteria. Colour sorters are examined in food processing, medicines, recycling, and agriculture. A conveyor belt-mounted optical sensor captures images of things in the colour sorter. Advanced algorithms and image processing techniques extract colour information from photos for accurate colour identification and distinction. The system sorts things by comparing detected colours to predefined criteria. Colour sorters in computer-integrated production systems have many benefits. It enhances sorting efficiency and accuracy, boosting production. Automating sorting lowers manual labour and human error. Colour sorters remove defective or inappropriate items from the production line, reducing waste and optimising resources. This project also shows the importance of colour sorters in modern manufacturing. Computer integrated manufacturing systems enable efficient, accurate, and reliable sorting. Colour sorters improve product quality, customer satisfaction, and waste reduction by automating and following criteria. Colour sorters will shape the future of industry as technology advances.

Introduction

Colour sorters are an important part of computer-integrated manufacturing systems and have changed the way things are sorted by color. These automated machines use sophisticated optical sensors and imaging technology to figure out the color of each item as it moves along a conveyor belt. By doing this, they sort the items into different streams or bins based on criteria and rules that have already been set. Color sorters are used a lot in industries like food processing, pharmaceuticals, recycling, and agriculture. They have made industrial processes much more accurate, efficient, and productive.

The main idea behind a color sorter is that it can tell things apart and put them into groups based on their colors. At the beginning of this process, an optical sensor takes a picture of the item as it moves along the conveyor belt. The picture is then looked at using complex algorithms and image processing methods. These algorithms pull out important information about colors from the picture. This lets the system recognise and tell the difference between different colors. Once the color is known, the colour sorter checks it against criteria and rules for sorting that have already been set. Depending on the business and the use, these criteria may be different. For example, in food processing, the color sorter can be set to get rid of fruits and veggies that aren't the right colour or are broken. This makes sure that only high-quality food gets to consumers. In the process of making pills, the colour sorter can find and separate capsules or tablets with the wrong colour coats. This keeps mistakes from happening with the pills. Color sorters are flexible because they can be changed to sort different things and meet different sorting needs. They can be set up to put different coloured items into different streams or bins based on how they look. This makes precise separation possible. Some advanced models can even sort things based on more than one factor at once, such as colour, size, and shape. This gives them a wide range of sorting options.

There are many benefits to putting colour sorters into computer-integrated industrial systems. First of all, they make the sorting process much more efficient. Colour sorters can quickly analyse and sort a large number of items because they have high-speed conveyor belts and real-time image processing. This not only saves time, but it also cuts down on physical work and errors made by people. Second, colour sorters make the sorting process more accurate and consistent. The advanced imaging technology in these machines makes sure that they can accurately identify colors.

This means that they don't have to rely on human operators, who might make subjective decisions. This makes sorting more consistent and reliable, which improves the standard of the products and makes customers happier. Colour sorters also help cut down on waste and make the best use of resources. By automatically separating objects by colour, they can get rid of broken or unsuitable ones from the production line, stopping problems further down the line and cutting down on waste. In recycling centres, colour sorters are essential for sorting the different types of recyclable materials. This makes recycling more efficient and less harmful to the environment.

1. Research Background

Colour sorting technology has changed the way things are made by making it easier and more accurate to sort things naturally based on their colour. With the rise of computer-integrated manufacturing systems, it is more important than ever to use colour sorters to improve the efficiency of production processes in many different businesses. In old manufacturing systems, sorting things by colour was mostly done by hand, with workers using their eyes to look at the items and separate them. But this method took a long time, made mistakes, and wasn't consistent. Because of the need for automated sorting systems, colour sorters were made. These machines use optical sensors and imaging technology to find and sort items based on their colour. This project's study background is made up of several important parts.

First, it includes a thorough understanding of how optical sensors and image processing methods can be used to find and analyse colours. This means looking into the improvements in sensor technology, such as high-resolution cameras and complex algorithms, that make it possible to identify and distinguish colours more accurately. Second, the study background includes a look at how colour sorters are used in different industries. For example, colour sorters are used in the food processing industry to separate fruits and veggies based on how ripe they are or to get rid of discoloured or broken food. In the pharmaceutical business, colour sorters are very important because they find capsules or tablets with the wrong colour coatings and take them away. This makes sure that medications are safe. In the same way, colour sorters are used in recycling and farming to quickly separate different types of materials or crops based on their colour.

Also, it is important to understand how colour sorters fit into computer-integrated manufacturing processes. This means studying how the colour sorter and other parts of the manufacturing system, like conveyor belts, robotic arms, and computer systems, connect and talk to each other. The background study also looks into how colour sorters can be programmed and changed to work with different objects, sorting criteria, and production needs. The background study for this project should also talk about the advantages of using colour sorters in manufacturing. Some of these are better efficiency, lower labour costs, higher yield, better product quality, and less waste. By automating the sorting process, colour sorters reduce the chance of mistakes, make sure the results are uniform and reliable, and make the best use of resources.

2. Problem Statement

1. Manual Sorting Limitations: Manual sorting in color-based manufacturing is time-consuming, error-prone, and inconsistent. Humans can't categorise a lot of objects by colour, which reduces productivity and quality.
2. Manufacturing wastes resources without automatic colour sorting. Defective or inappropriate objects may not be discovered and removed from the production line, causing waste and downstream issues.
3. Lack of Precision and Flexibility: Color-based manual sorting is typically inaccurate. When sorting complex products with several criteria like size and form, failure to distinguish minor colour differences inhibits efficiency.
4. Modern industrial systems require speed and throughput that manual sorting cannot meet. Manual sorting slows production, generating bottlenecks and inefficiency.
5. Human Error: Colour sorting by humans risks subjective judgements and human error. Operator inconsistency might misclassify products, lowering quality and dissatisfying customers.

3. Objective and Scope

1. To design, develop, and deploy an automated color sorting system for computer integrated production systems. Using optical sensors and image technology, the system will detect and classify things by color, enhancing sorting efficiency and accuracy.
2. The initiative intends to reduce waste and downstream problems by removing defective or inappropriate items from the production line. It will overcome manual sorting restrictions and improve color segregation based on predefined sorting criteria.
3. To improve productivity and reduce human labor for color sorting. Automating sorting reduces human error, improves consistency, and boosts industrial productivity.

Literature Review

1. **Design and Development of an Automatic Color Sorting Machine on Belt Conveyor. Thike, Aung et al (2019)[1]**

The design and development of an automatic colour sorting machine that runs on a belt conveyor system is presented in this study. The purpose of the research was to develop a colour sorting machine that is both efficient and cost-effective, with the intention of making it applicable across a variety of business sectors, including the food processing industry, the recycling industry, and the agricultural sector. The authors wanted to create a system that could accurately detect and sort things based on their colour while also integrating themselves smoothly with a belt conveyor in order to perform continuous sorting operations. The components of the colour sorting machine, including hardware and software, are broken down into excruciatingly specific detail throughout the course of this article. The hardware consists of a camera with a high resolution for photographing the objects to be sorted, an illumination source, a light source, a belt conveyor system for transporting the products, and an actuator mechanism for placing the sorted items in the appropriate containers. In terms of the software, the authors created an image processing algorithm in order to analyse the colour information that was taken from the photos that were captured. In order to accurately categorise items based on the colour attributes of those objects, the algorithm makes use of colour space conversion techniques, thresholding, and feature extraction methods. After the objects have been sorted, they are placed in the appropriate containers according to the sorting rules that were previously established. The authors put their newly designed colour sorting system through its paces in a number of studies in order to evaluate its effectiveness. They put the system through its paces by using a variety of objects with a wide range of colour distinctions. The findings showed that the system was effective in precisely sorting objects based on the color features of those objects, attaining a high sorting accuracy and throughput as a result of its work.

2. **Application of computer vision technique on sorting and grading of fruits and vegetables. Mahendran, R., G. C. Jayashree et al (2012)[2]**

In this study, researchers investigate how computer vision techniques might be used to classify and categorise different types of produce, such as fruits and vegetables. The purpose of the research was to evaluate whether or not it is possible to use computer vision technology to automate the sorting and grading processes that are used in the food business and whether or not it is effective in doing so. The authors' objective was to devise a method that could accurately categorise fruits and vegetables according to their qualitative characteristics, which included aspects such as size, colour, and form. In this publication, a full review of the computer vision techniques used in the study is provided. The hardware setup is described by the authors, and it consists of a high-resolution camera for taking pictures of the produce, appropriate lighting setups, and a conveyor system for transporting the objects. In addition to that, they talk about the software components, such as image processing techniques and classification models. The study utilised image processing methods that included pre-processing processes such as picture enhancement, segmentation, and feature extraction. These steps were implemented in the study. Because of these stages, it was possible to extract useful features from the photographs, such as the strength of the colours, the parameters of the shapes, and the characteristics of the textures. These characteristics were utilised by the authors in the creation of classification models through the application of methodologies such as decision trees, support vector machines (SVM), and artificial neural networks (ANN). Experiments were carried out by the authors using various kinds of fruits and vegetables so that they could evaluate the effectiveness of the system that had been established. The results revealed that the computer vision system was accurate and successful in sorting and rating the produce based on the quality characteristics that each item possessed. With a great degree of precision, the system was able to separate and categorise the many types of fruits and vegetables into distinct grades and groups. The benefits of using computer vision technology in the food sector, as well as its possible applications, are discussed in the final section of this study. The authors emphasise the potential of the system to improve the efficiency and uniformity of sorting and grading procedures, reduce the amount of manual labour required, and guarantee the quality of the result. In addition to this, they highlight potential new paths for research, such as the use of sophisticated image processing methods and the introduction of the system into automated manufacturing lines.

3. **Development Of Industrial Automatic Multi Colour Sorting and Counting Machine Using Arduino Nano Microcontroller and TCS3200 Colour Sensor. Sachdeva, Amitesha, et al (2017)[3]**

The Arduino Nano microcontroller and the TCS3200 colour sensor were utilised in the creation of the industrial automatic multi-color sorting and counting machine that is described in this study. The purpose of the research was to design and construct a colour sorting and counting machine that was both efficient and cost-effective, and which could be utilised in commercial and manufacturing environments. The authors wanted to create a system that could accurately recognise and categorise objects according to their colour while also delivering a count for each colour group. This was one of their goals. The paper gives a comprehensive account of the different pieces of hardware and software that went into the making of the colour sorting and counting machine. The authors made use of a TCS3200 colour sensor and an Arduino Nano microcontroller as the primary components of the central control unit. In addition, the system had a conveyor mechanism for the conveyance of things as well as a device for redistributing the objects that had been sorted into the appropriate containers. The operation of the machine was controlled by the software that was implemented, which entailed programming a microcontroller based on the Arduino Nano platform. The colour sensor was calibrated so that it could accurately identify the various colours, and the relevant algorithms were constructed so that the items could be sorted according to the colour information they contained. The machine was developed to count and record the amount of objects that fell into each colour group. This would provide useful data for a variety of industrial applications. Experiments were carried out by the authors utilising a wide variety of objects of varying hues so that they could evaluate the effectiveness of the newly built machine. The findings revealed that the system was effective in correctly classifying things according to their colour and providing an accurate count of the number of objects in each colour group. The advantages of the newly constructed machine are discussed in the final section of the study. These advantages include the machine's cost-effectiveness, efficiency, and ease of implementation. The authors also highlight the possible applications of the system in industrial contexts, including the manufacturing industry, the food processing industry, and the recycling industry, amongst others. They explore the scalability of the system as well as potential future upgrades, such as the integration of more sensors or the implementation of machine learning algorithms for more complicated sorting jobs.

4. **Design and development of the vision sorting system. Tho, Tuong Phuoc et al (2016)[4]**

The design and development of a vision-based sorting system is the main topic of discussion in this study. The purpose of the research was to figure out how to design a sorting system that is both effective and precise, and that makes use of vision technology to automatically categorise things based on the visual features they possess. The authors' goal was to design a system that could be used in a variety of fields, such as the production of goods, the processing of food, and recycling, among others. The design and development process of the vision sorting system is broken down in great detail during the course of this article. The authors go into the many pieces of hardware that were utilized, such as a camera with a high resolution for the purpose of image acquisition, suitable lighting setups, and a conveyor system for the purpose of object transportation. In addition to this, they provide further information on the software components, such as image processing techniques and classification models. The image processing algorithms that are utilized by the system make use of a variety of methods, some of which include image enhancement, segmentation, and feature extraction. These methods make it possible to extract important visual characteristics from the photos that have been collected. As a result, it is now possible to categorize things according to characteristics such as their color, shape, or texture. In order to accurately categorize the items, the authors explore the application of classification methods such as decision trees and neural networks. Experiments were conducted with a variety of objects and a wide range of sorting criteria in order to test the effectiveness of the vision sorting system. The findings provided evidence of the effectiveness and precision of the system in classifying objects according to the visual attributes of the items. The system was successful in separating the items into their respective categories or classes, hence delivering an efficient and effective automated sorting solution. The study discusses the built vision sorting system, stressing its benefits as well as the prospective uses for it. The authors examine the system's potential to improve sorting efficiency while also lowering the amount of manual labour required and providing results that are consistent and dependable. They also address future directions for research and development, such as increasing the system's capabilities for real-time processing and incorporating it into an automated production line, among other things.

Methodology

The objective of this project is to sort raw materials into three different belts based on their color using various components such as belts, pushers, and sensors. Belt Configuration: To begin, the project utilizes several belts, including a six-meter belt configured to move in a counterclockwise direction. A curved belt is also employed, with its configuration set to ensure proper movement. The direction and arrow indicators on the belts are carefully considered to ensure efficient material flow.

1. **Raw Material Sorting**

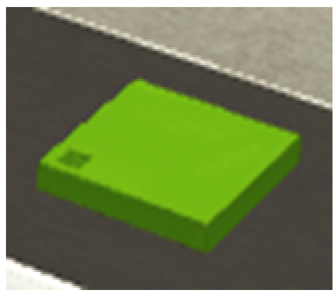

Figure 3.1: Green Colored Raw Material

The raw materials are sorted into three different belts. To achieve this, the initial belt configuration is duplicated to create three separate paths. These duplicated belts will serve as destinations for the sorted materials.

2. **Pusher Implementation**

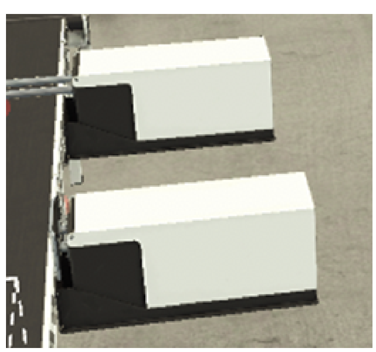

Figure 3.2: Pusher

To prevent parts from scattering and ensure proper sorting, a pusher mechanism is utilized. A centrally positioned pusher is placed on the fish belt. This pusher is responsible for moving the materials onto their respective paths. Without the pusher, the parts would disperse randomly, hindering the sorting process.

3. Fishing Sensor Integration

Figure 3.3: Fishing Sensor

A fishing sensor is employed to detect the green raw material. The sensor is strategically positioned in the middle of the fish belt. The fishing sensor is set to be triggered and output a signal when it detects the presence of green raw materials. This signal is used to activate the pusher and initiate the sorting process for the green parts.

4. **Conveyor belt**

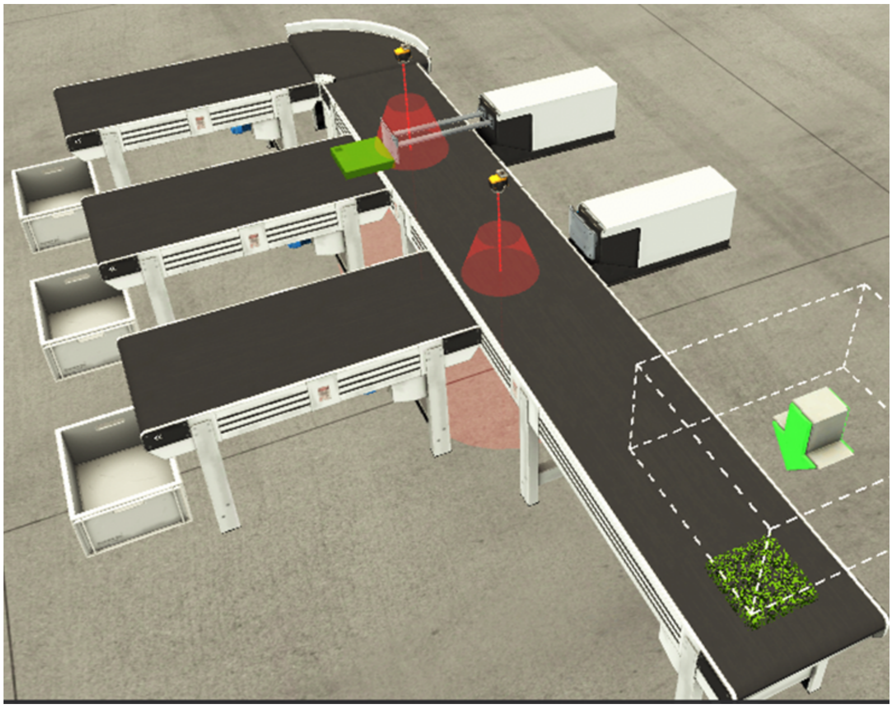

Figure 3.4: Conveyor Belt

Multiple types of conveyor belts are employed in the color sorter setup. A six-meter belt is prominently featured, which is configured to move in a counterclockwise direction. This belt is used to transport the raw materials along the sorting process. Additionally, a curved belt is utilized to ensure smooth movement around corners.

The methodology employed in creating the color sorter in Factory I/O involved configuring belts, duplicating belt paths, implementing pushers, integrating fishing sensors, utilizing logic gates, and fine-tuning the setup for stability and practicality. By following this methodology, the color sorter successfully separates raw materials based on their color, demonstrating the effective use of components and logical control in Factory I/O.

Result

1. Discussion

The color sorter project in Factory I/O successfully achieved its objective of sorting raw materials based on their color using conveyor belts, pushers, and sensors. The implemented methodology effectively controlled the movement of the belts, allowing the materials to be directed to their respective paths for sorting.

Figure 4.1: Pusher did not Push the Gray Raw Material to Green Box

The pusher mechanisms, triggered by fishing sensors, accurately pushed the materials onto the designated belts. The logic gates and Control IO components ensured precise and controlled movement of the pushers. By following the methodology, the color sorter demonstrated reliable and efficient sorting of green and blue raw materials. The project serves as a successful example of utilizing Factory I/O for automated sorting processes.

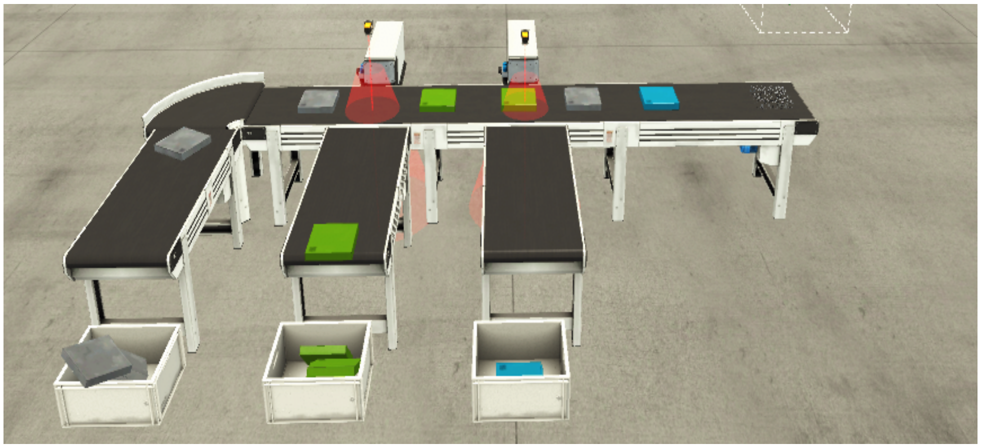

Figure 4.2: Pusher Pushed Green Raw Material

2. Future Improvement

Although Factory I/O offers numerous advantages, it still has several disadvantages compared to other state-of-the-art 3D simulation software. Some of these disadvantages include the limited object that can be used for simulation. Since it is not possible to add new industrial components, users are limited to the current library which has been provided by software. Another limitation it possesses is that it is quite hard or nearly impossible to measure the size of the provided item in Factory I/O to have them to be equal in size (e.g. 1:1 scale) to the real industrial components. This limits those who would like to create a specific project which needs to be implemented into a real situation where exact diameter, length, width, and many other measurements play an important role to make sure that it can fit the industrial space. In order to tackle this problem, digital twin can be an alternative solution for further improvement.

Digital twin is a visual representation or model of a physical object, system, or process. It is a digital counterpart that mirrors the physical entity in terms of its attributes, behaviour, and characteristics. It replicates the physical entity in a digital format and encompasses not only the geometric shape and appearance but also the functional and behavioural aspects. It includes data about the structure, components, sensors, and actuators that make up the physical system. The digital twin concept aims to bridge the gap between the physical and digital worlds, allowing for improved understanding, analysis, and optimization of real-world entities. There are several software which are able to perform specific tasks for industrial manufacturing processes. Luma

AI, Blender, and NVidia Omniverse are examples of the software. These three softwares have been used by industrial manufacturers to create digital twin of industrial grade components for implementing it and to the surrounding environment for specific purposes.

2.1 Luma AI

Luma AI is an innovative artificial intelligence tool that empowers users to produce incredibly realistic 3D visual assets with just a smartphone. It is a great and powerful tool known for creators to capture and transform real-world objects into photorealistic digital assets. The software lets users use any camera to take 360° capture or video and turn them into certain 3D models. In this project case, a specific industrial grade robot needs to be 360° captured to obtain the digital 3D model. After the model is generated, the user can convert the mesh into a variety of formats, such as GLTF, OBJ, or USDZ, to suit the user requirements. The size and measurement of the digital 3D model can be adjusted later on for specific requirements needed by the user. It is very effective and recommended to use for any user who wants to create their own 3D environment with a very specific 3D model.

Figure 4.3: Luma AI Logo

To have optimal results when using this software, there are several things needed to be done before the capturing process. First thing first is to make sure to disable HDR in the camera setting. After it is disabled, the user needs to capture the object by moving 360° creating a loop around the object and ideally three different loops with different heights each need to be captured for the best result. The first height is at chest level, and the second one around head level with the camera facing downwards, and lastly at knee level with the camera facing upwards. All of these captures needed to be down slowly to reduce blur and enhance the overall quality of the images. After the capturing process is complete, Luma AI will generate the 3D mesh for the user.

Despite the effectiveness and practicality of Luma AI, it has several disadvantages as well. In several industrial cases, where most of the robots are usually moving and caged so they will not harm any worker in process, it will be quite hard for the user to take a full loop capture around the desired object since any movement during the capturing process might degrade the quality of the final 3D model. Not to mention other factors such as the location of the robot or the space where the robot is located can play factors in capturing the robot. The user always needs to maintain its distance to the object and the lightning condition to provide more data for accurate reconstruction.

2.2 Blender and NVIDIA Omniverse

Blender is a powerful open-source 3D creation suite that offers a wide range of features for modeling, animation, simulation, and rendering. It is often used in various industries, including architecture, manufacturing, and visual effects. With Blender, users can create detailed 3D models and environments to represent the physical entities in digital twin. It supports advanced rendering techniques, animation capabilities, and physics simulations, which can be valuable for creating realistic and dynamic digital twin representations.

Figure 4.4: Blender logo

In this project case, several models can be downloaded from blender itself or the internet. These models sometimes can be a result of a digital twin process using software such as Luma

AI or fully created by a 3D digital artist. Some charge their models for several dollars while some others can be found for free. In most cases it can be found that paid models have better quality, but it cannot be completely said that the free ones have low quality. For industrial robot models, blender usually gives out several free top grades models which assemble the exact measurement or size of the real one. Several models like conveyor belt and end-effector can be seen below creating a manufacturing process line.

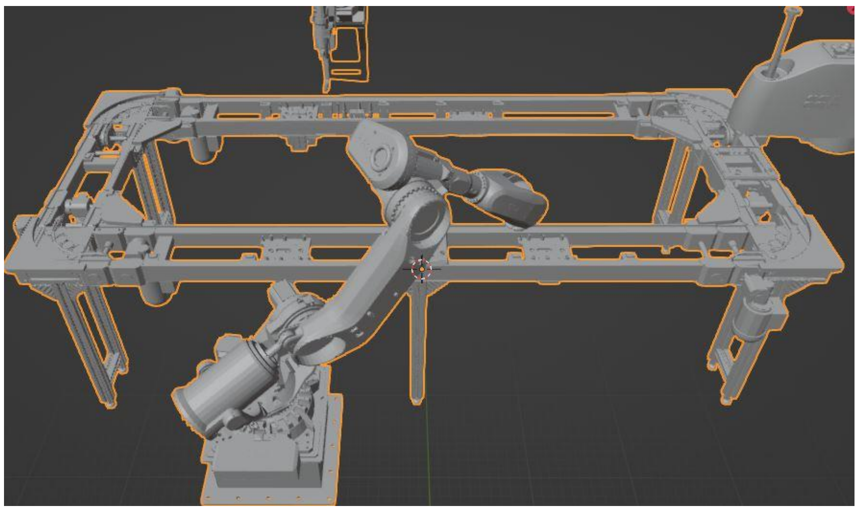

Figure 4.5: Downloaded Blender Model

NVIDIA Omniverse is a platform for real-time collaboration and simulation, designed to facilitate the creation and management of complex 3D environments. It provides a shared virtual workspace where multiple users can work together on creating, visualizing, and simulating digital twins. Omniverse supports real-time rendering, physics simulations, and the integration of various 3D assets. It also allows for seamless data exchange and collaboration among different software tools and systems.

Figure 4.6: Nvidia Omniverse

By combining the capabilities of Blender and NVIDIA Omniverse, users can leverage Blender's robust modeling and animation features to create detailed 3D models, and then import those models into NVIDIA Omniverse for real-time visualization, simulation, and collaboration. This combination allows for the creation of interactive and immersive digital twin environments that can be easily shared and explored by multiple stakeholders.

Conclusion

In conclusion, the objective of designing, developing, and deploying an automated color sorting system for computer integrated production systems holds significant potential in enhancing sorting efficiency and accuracy. By incorporating optical sensors and image technology, the system can effectively detect and classify items based on color, mitigating waste and downstream issues by removing defective or inappropriate items from the production line. Automation eliminates the limitations of manual sorting, improving color segregation based on predefined criteria. Moreover, the implementation of such a system can lead to increased productivity, as it reduces human error, ensures consistency, and minimizes the need for manual labor in color sorting processes.

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