Saimaa University of Applied Sciences
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Technology
Mechanical Engineering and Production Technology

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Designing a mobile portal station for Artec Eva 3D-Scanner

Thesis 2019

Abstract

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Designing a mobile portal station for Artec Eva 3D-Scanner, 33 pages
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The objective of the study was to create a model of a station for stable movement of 3D scanner Artec Eva. The main purposes were to make it easy to assemble and disassemble, safe to use and be constructed with elements, which are easy to find on the market. Another goal was to get the lightest weight possible so that the transportation would not cause any troubles.

This study was carried out in Solidworks with the help of Bosch's CAD drawings. It was started with a basic concept assembled out of Bosch's parts. These parts were selected as the basement for the whole construction due to their reliability proven by years of exploitation. Several fasteners and pulleys were designed according to situational requirements. The whole designing process was carried out relying on the project purposes.

The final result of this thesis was the model accepted by supervisors. It fits most of the goals that were set in the beginning. There were shown aspects that must be implemented in real life. Positioning for each detail was selected leaning to the set purposes.

Keywords: model, 3D scanner, structure

Contents

Terminology

3D – three dimensional
Mm – millimetre
M - meter
Kg – kilogram
CAD – computer-aided design

1 Introduction

The request for this project was received from the Saimaa UAS laboratory mechanic Timo Pukki, who had a strong necessity in a 3D model for the scanning purposes ordered by the university. During his experience of utilizing 3D scanner Artec Eva by handling it himself, he found out that it does not fit for measuring huge objects, which dimensions are more than 1 meter in any direction. That is why he came with an idea of a mobile portal station, that provides stable motion of the scanner fastened to the structure.

This project is based on the modeling principles learned during the studying process, the experience of supervising members and a strong attitude to reach the given goal. The designing process was fully carried out with the help of Solidworks software.

1.1 Objectives

The scientific group of Saimaa University of Applied Sciences established a goal for this thesis work as designing a mobile portable station for Artec Eva 3D-scanner which is frequently used for producing the models of different technological objects. The method of utilization of this scanner is mainly handled, which is not convenient and causes several troubles while making scans larger than one meter in any direction.

According to this reason, there appeared an idea to design a structure that could carry the scanner precisely along all the trajectory needed. The scanner needs to be mobile in all 3 directions which means that the construction needs 3 degrees of freedom. It was determined that the maximum y-direction length needed is 2.5 meters, x-direction width is 2 meters and z-direction depth is 60 centimeters. One more point of the goal was that the system must be portable which means that the weight should be as low as possible and it should be easy to assemble or disassemble it in a short period of time and with high precision.

That is why it was decided that the structure is going to be assembled with yhe help of Bosch framing profiles with which everyone in the university is familiar and, according to the experience of senior members of the staff, Bosch has recommended itself as a completely reliable choice. Moreover, they have another kind of production which is also going to receive a notable role in the project. These are Ball Rail Systems which are perfect for stabilized linear motion. The runner blocks are quite expensive, but they are extremely precise, and the coefficient of friction is only around 0.03, which leads to a lower requirement of torque for the motors and reduces the overall weight of the construction.

1.2 Method

The project model is carried out with the help of SolidWorks 3D-CAD. For most of the components, there are available CAD models on Bosch's website. Also, some of the fastening parts are found there, others are drawn by the executor, and could be easily manufactured at the university's laboratory. All the screws, nuts and bearings in use are from the official Toolbox so that they correspond the ISO standards. The connections between bars are easily disassembled and this makes it possible to pack all the construction into a long but slim box and transport to a new place of work. The scanner itself is connected to the lower end of the z-axis bar via the articulated hydraulic arm, which makes all positioning angles possible.

1.3 Structure of thesis

The thesis consists of three main chapters:

- The first one is about the confines and basic theory of 3D scanning
- The second includes the chronology of taken actions and reasoning of made solutions to achieve the ready model
- The last one describes model parts one by one, assembly parts and shows the overall result that combines all the parts together

2 The confines and theory

The processing of the thesis, which project model should result in a real-life structure demands several confines and theoretical background about the object around which the whole model is built.

2.1 Safety issues

The safety recommendations for the device are simple and do not contain anything special. There are no high speeds possible during the exploitation.

Nevertheless, several sharp edges might occur, so that during the assembling the construction it is recommended to wear gloves. But when the system is in use, space, in which motion is possible, should not be interacted. Any extraneous subjects might cause a breakdown because the system is not strong enough to pass through any collisions. This is caused by orientation on the lightness.

2.2 Maintenance

The casual maintenance is required as removing dust and lubricating moving parts should be provided to avoid jams of mechanisms. Due to slow-moving speeds, there are no visible fast wearable parts noticed. That is why no recommendations about spare parts are revealed.

2.3 Costs

Most of the parts must be purchased on the market or directly from the manufacturer. Some of them are expensive, but the decision was made to choose high-quality parts that will serve for a long period of time without causing an inability to use the whole construction because of one simple breakdown.

The main number of designed parts are easily manufactured out of cheap aluminum plates so that their cost is neglectable. Drive pulleys are left in designed parts and were not found on the market. Their manufacturing might cause some time spends because of grooves needed to achieve friction with the carrying belts and connectors to the motor shaft. Simple pulleys could be manufactured much easier because of simplified shapes.

2.4 Size limits

The objective was to perform construction, which can accommodate an object approximately 2.5 meters long, 2 meters wide and 60 centimeters high. These dimensions were taken to define the lengths of the bars. The vertical bar is 1-meter hight because the working space of the scanner begins at the 40 centimeters distance from the source of rays.

2.5 Loads

Loads were estimated and compared to the values of limits of the components that were utilized. Almost all of the parts have a safe extra load capacity. Only the belt for the vertical axis was under a question because it had to carry the scanner itself, the motor, vertical bar, articulated arm, and all the fastening parts, the overall weight of which was around 2 kilograms. The appropriate belt was found and thankfully to the low moving velocities which do not cause much impact load the belt can carry all the parts of the structure without extra risk.

2.6 Theoretical 3D scanning background

Nowadays this technology is spreading across the universe due to its high precision, safety for human beings and multipurpose possibilities to use. The main principle of the technology is that 3D Scanner projects a template of encrypted light and collects the geometry of the selected object by projecting a tremendous amount of points which form the net. The net consists of lines between the points and merging all multiangle structures forms the surface. After that, all the gathered information is being processed by a computer with the help of a special program to produce the 3D model of the object.

There are several types of 3D scanning technologies available on the market but in this study, the main focus is going to be made on the structured light scanning technology because this is the technology with which Artec Eva scanner, the structure is modeled for, works. It is named the best 3D scanner for in the price category by several editors.

“This structured light 3D scanner is the ideal choice for making a quick, textured and accurate 3D model of medium sized objects such as a human bust, an alloy wheel, or a motorcycle exhaust system. It scans quickly, capturing precise measurements in high resolution.

Light, fast and versatile, Eva is our most popular scanner and a market leader in handheld 3D scanners. Based on safe-to-use structured light scanning technology, it is an excellent all-round solution for capturing objects of almost any kind, including objects with black and shiny surfaces.

Artec Eva’s ease of use, speed and precision has made it an essential product for a wide range of industries. From rapid prototyping to quality control, CGI to heritage preservation, the automotive industry to forensics, medicine and prosthetics to aerospace, the device is used to customize, innovate and streamline countless forward-thinking industries. Eva was even used to scan Barack Obama and help make the very first 3D portrait of an American president.” - www.artec3d.com

2.7 Instructions

First of all, after the first testing assembly, the construction should be divided into 6 main parts. Two of them are base 40 mm bars and aligned with the staff. The eft one without a motor does not have any connections to other parts, except the roller leg which just stands on its surface. The right base part is fastened to the right vertical bar with the help of a special plate which suits the holes on the upper surface of the base part runner block. These holes are threaded for the M3 bolt. These bolts are easily unscrewed for every disassembly process. There should also be an electrical connection and a USB cable for data transfer. They have a simple lock connection which is perfect for multiple connections and disconnections.

The scanner itself is connected with the help of M6 screw hole which is filled with the bolt on the end of the an articulated arm. It is simply unscrewed and packed to the special scanner case. The articulated arm could also be unscrewed from the Y-axis bar, if necessary. The bar is connected to the frame at the runner block surface, where it meets a similar runner block of the X-axis. This connection is also unscrewed due to the disassembly process. Then, the bar is packed into the appropriate package box.

The X-axis bar has to be disconnected from the vertical bars. Firstly, electrical connections should be removed, then the 90-degree fasteners unscrewed, and a lower fastener of the drive pulley should also be unscrewed from vertical bars.

After these steps are completed, all the bars and aligning parts could be packed in the same way as the Y-axis bar.

3 Chronograph

3.1 Overall description of meeting discussions

The first meeting was set right after there was received a topic from the program manager Jukka Nisonen. An appointment with the supervisor Mikko Ruotsalainen occurred. There was discussed the main idea of the thesis and set the date and time of the next meeting. We also determined the frequency of the future meetings and a rough deadline.

The task was to think about the concept of the construction and to draw a basic sketch that will show the path for forming a 3D model. What is more, another mission was to become familiar with the theory and gather some information about the 3D scanner, for which the construction is being developed.

The second meeting started with a discussion about the sketch that was drawn. The idea was simple, it was based on a 3D printer's construction. But an action to evaluate the mass and number of components was missed in this case so that it was not the best solution.

Another solution was developed, which required much fewer framing parts, which means less mass and less necessary power. The ext thing we talked about was the choice of possible profiles and motion principle.

The driving power was decided to be transferred with the help of the belt system. The positive sides of such a solution are easiness of realization and high reliability. But when it comes to the flexibility of variation of possible sizes, belts are causing serious problems, because the length of the belt determines unchangeable motion length. This fact may cause several inconveniences because in some cases when the size of the measured object is somewhere in the middle between the maximum possible size for the system and the size which is comfortable for hand-scanning.

Another option was to place the motors on each moving part and add a wheel to the motor, which makes every axis independently moving on the frame rails, which could be placed on the bars or the bar structure may include some kind of rails, even grooves in Bosh Rexroth bars could be used as rails.

After several estimations and consultations with the most practically experienced member of the team, who made everyone sure in grounds of made choice in favor of a belt-driven system. The main disadvantages in the rail-based system were difficulties to establish it in real life without numerous customized components, while for the belt based on most of the components could be found on the market.

During the following week, the process of modeling a concept with belts and some connections between bars took place. More than that there were some initial ideas of moving parts that could solve several problems that appear while trying to materialize the overall structure principle. It was a self-designed connection module, but after some analysis and network search the Rexroth Runner Block was found. It looked perfect according to the requirements for these elements, but the cost was quite high. After a discussion with the supervisor and customer, it was decided that this kind of a solution suits better than a self-designed element, even though it could appear cheaper, but less reliable in long term use.

The exploration went deep into Bosh's Rexroth production to find the best components that will fit each other. It came out that there is already existing a similar type of structure which could be possible to introduce it to the system which is developed in the work. The reason why this idea was declined is that the weight could become significantly higher and the overall cost would also increase. After the searching process, the final choice was determined for each moving axis. These were two stainless steel runner blocks of the 15th size and rails for them plus one 20th size runner block for the base part.

Another task appeared when the question stood up at a motor point. There were several options about the type and placement of the motor and most of them were not great to implement. They also require some extra gearbox and then came out an idea to find a readymade motor with a 90-degree gearbox initially provided. The mass of the motor and gearbox is 250 grams, so all the motors together weigh only 750 grams, which is not a lot. It is also widely available on the market and in many configurations.

To achieve a certain degree of freedom for the scanner connected to the system, an articulated arm was suggested as a solution. There was one in the laboratory, which served as an example in real life. But it was too small and that caused a necessity to find one on the market to fulfill the load and size requirements. The model was not found, that is why the design was produced as a part of the work.

4 Model parts description

4.1 Y-axis bar and articulated arm with connected scanner model

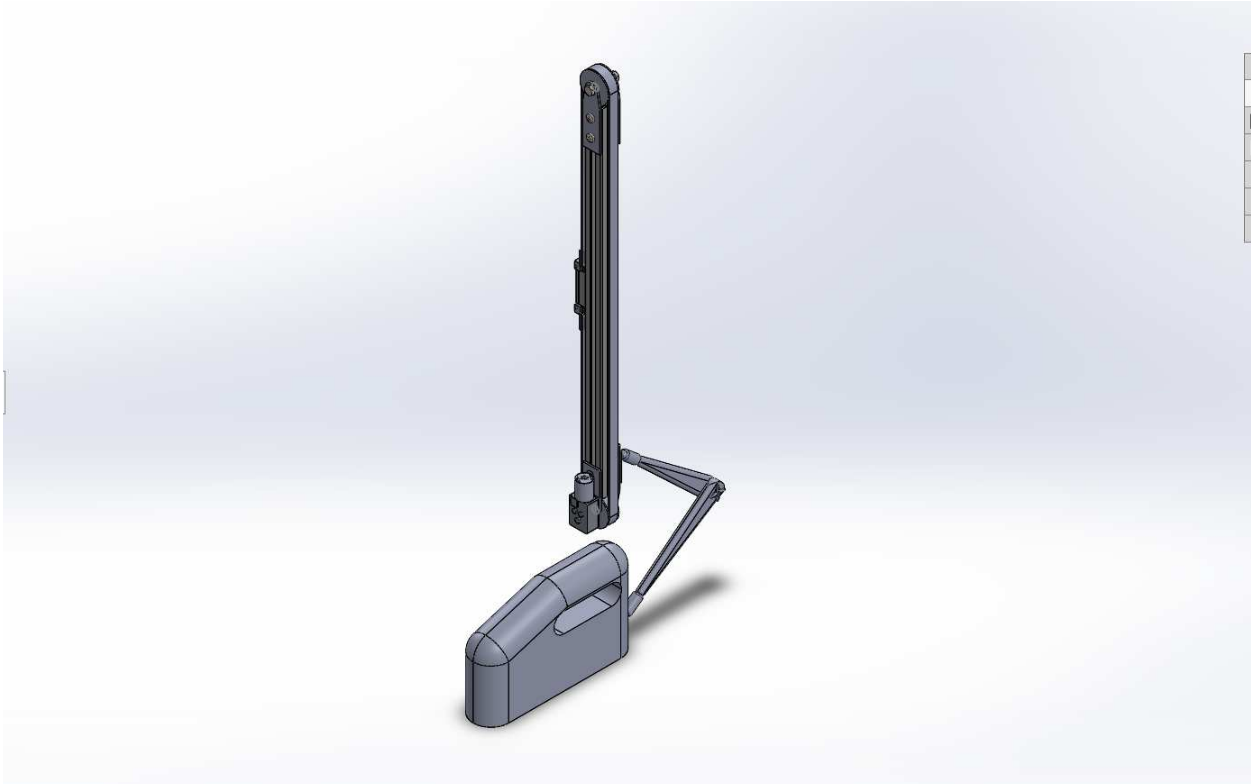

Figure 1. Y-axis assembly

This image illustrates the Y-axis 600 mm bar with an articulated arm, which is connecting the bar and scanner. The rough model of the scanner is also shown there. All the dimensions of the scanner have complied with the dimensional data observed from the official website of Artec.

As all moving axis bars, this one has pulleys on its ends to hang the belt. They are fixed with the help of side fixing plates. The plates are penetrated with bolts to achieve the fixation with the bar and provide an axis for a rotational degree of freedom.

There are bearings inside each pulley, which makes the motion smoother. Their positioning is defined by nuts and washers, which also fix the axis bolt. On the lower left side were placed the fixing plate for the motor and the motor itself. On the opposite side, there are two layers of fixing plates. The second one is for the articulated arm fixation. The backside is occupied with the rail for the runner block. The joints between the bar and the rail must be prepared before assembling. There are no holes provided for this conjunction, so the extra ones should be drilled.

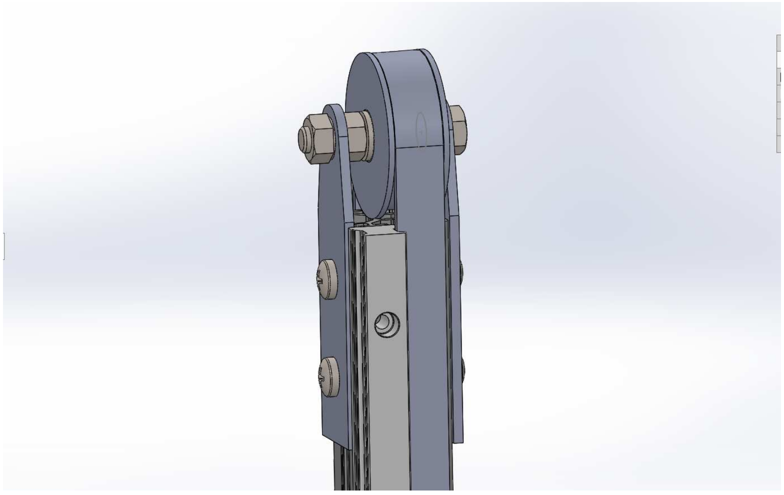

Figure 2. Upper end of y-axis assembly

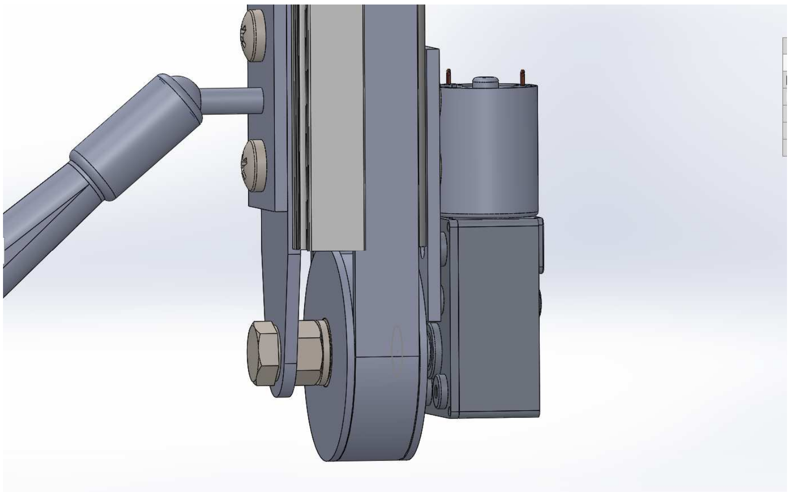

Figure 3. Lower end of y-axis assembly

In the pictures above the endings of the y-axis, the bar is shown closer to observe the principles described above. They are both taken from the backside to display the most important parts of the assembly.

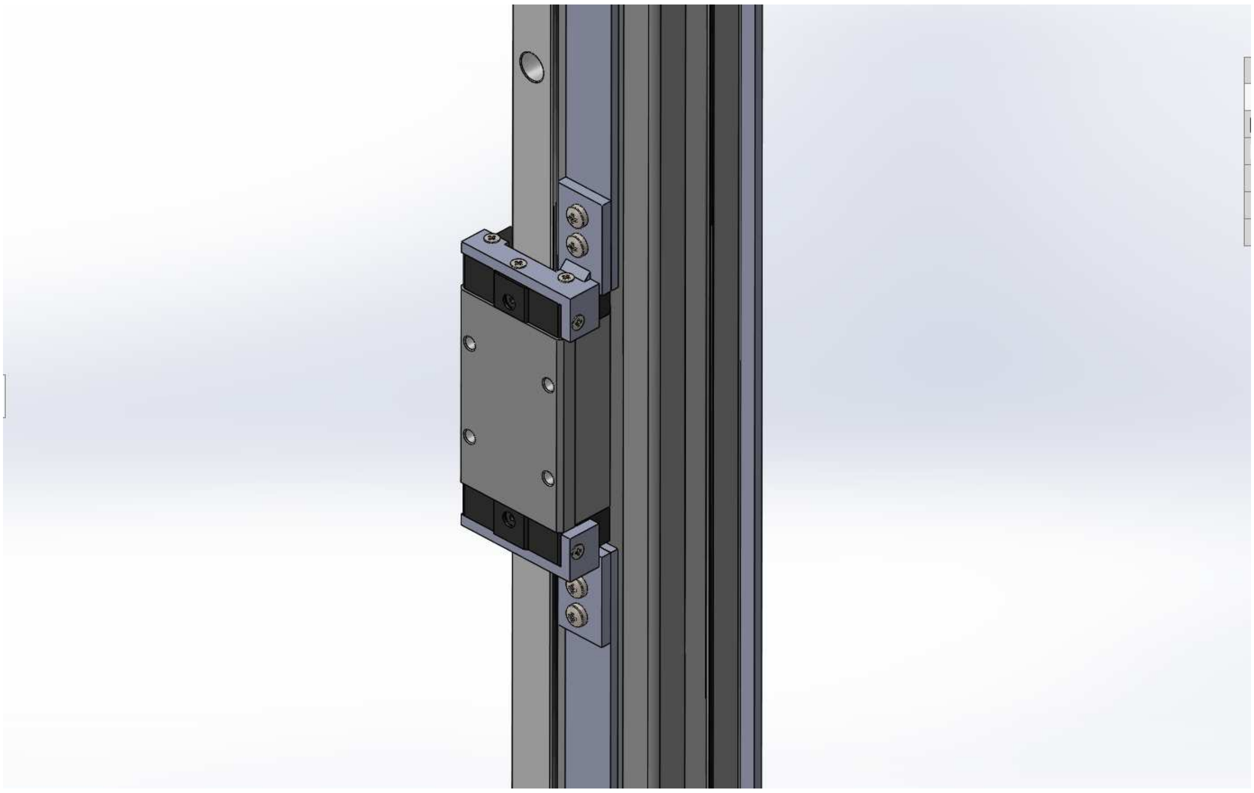

Figure 4. Y-axis runner block

This figure illustrates mainly the running block connected to the belt. The connecting plates are strengthened to carry the load which is around 2 kilograms. 4 bolts are used to execute the connection from plate to runner block.

4.2 X-axis or the main frame

Figure 5. X-axis assembly

In this picture, the largest part of the construction is shown. There is the x-axis motion system connected to the 2000 mm long 30 mm wide bar and two 1000 mm long 30 mm wide bars on the sides to provide vertical spacing. In the lower groove 10 pins with bearings are placed which are serving the possibility for hooks to be hang ed and provide the wiring for motor and scanner.

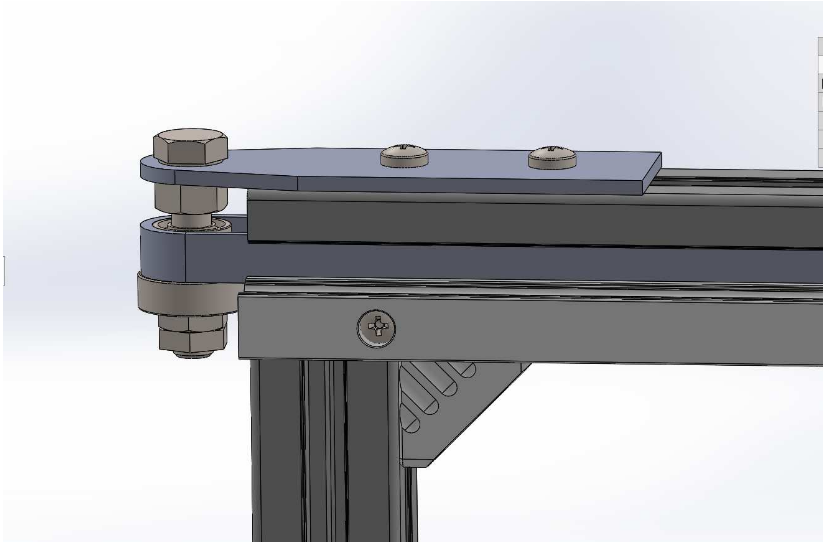

Figure 6. Left end of x-axis assembly

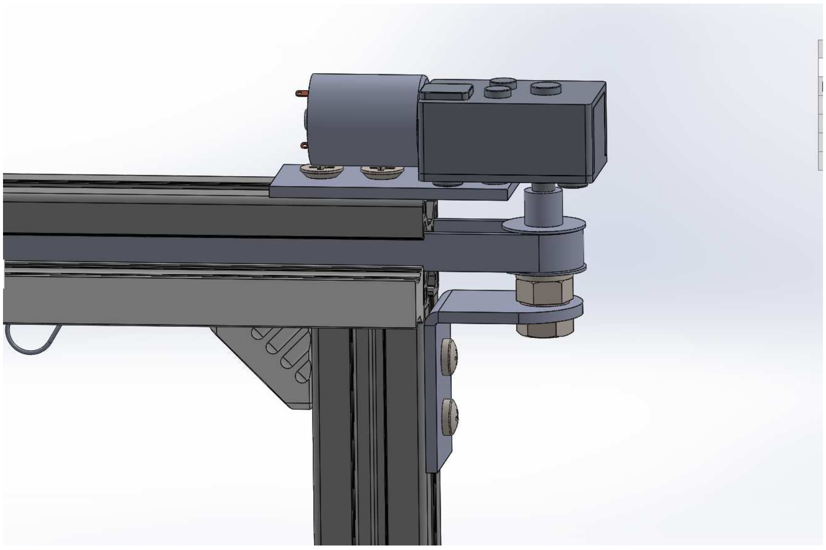

Figure 7. Right end of x-axis assembly

On the left side of the frame, the connecting plate is penetrated with the M8 screw to proceed the axis for the bearing, which is carrying the belt. There are two nuts on the end of the screw to fix the possibility of vertical motion of the bearings. The lower bearing has a bigger diameter which is equal to the diameter of the belt. Right after there are two smaller bearings, each 5 mm wide to achieve the belts' width. Upper than them there is one nut to fix the screw with the plate.

On the right side, the x-axis motor is placed. It is connected to the pulley, which is supported by a 90-degree plate. The plate is penetrated with an M8 screw and it is carrying the bearing on the end, which goes inside the pulley and takes a part of the load from the motor shaft. There are one nut and a washer between the surface of the plate and the bearing.

Vertical bars are connected to the horizontal with the help of Boschs' 90degree fasteners. They are perfectly designed for fast assembling and disassembling, which makes it easy to transport each bar separately.

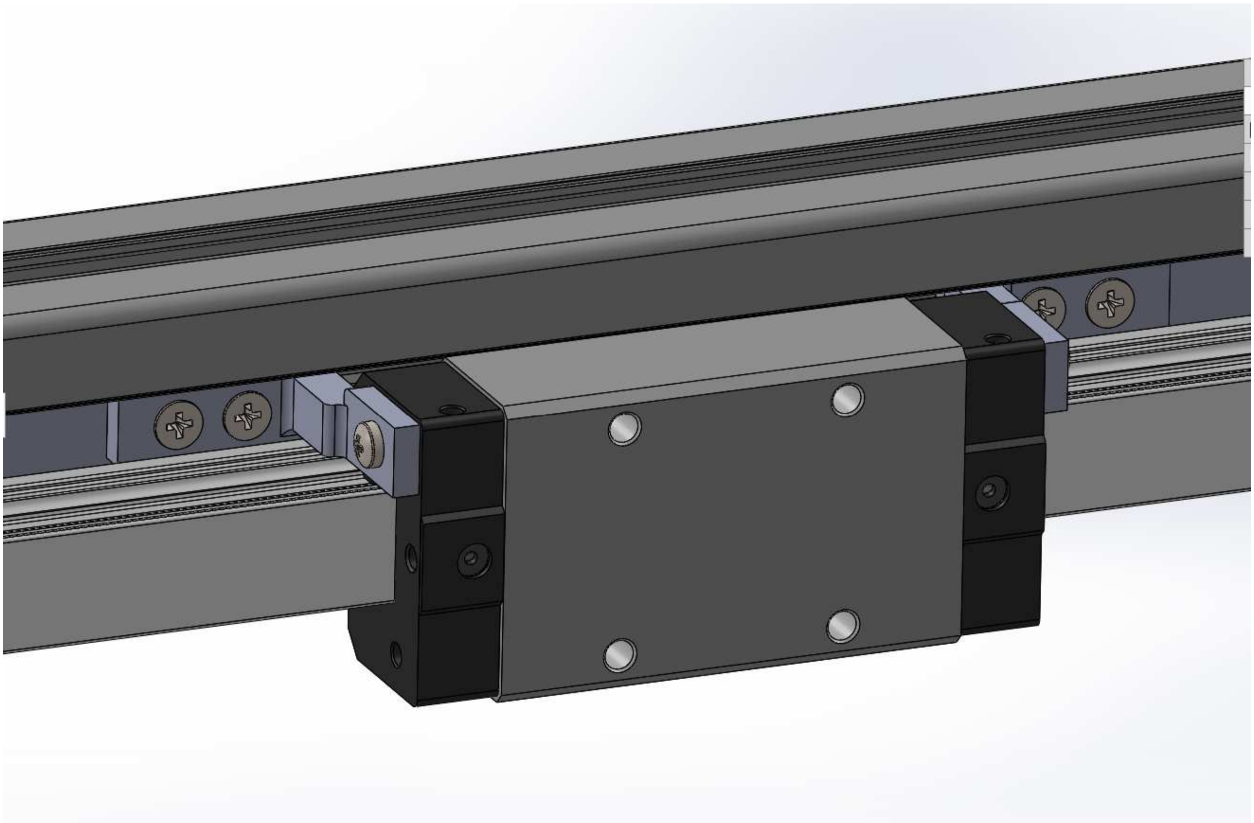

Figure 8. X-axis runner block

The x-axis runner block is connected to the belt with fixing plates. The belt connected to this runner block carries the least load among all the belts, that is why there are no strengthening elements in the plate's construction.

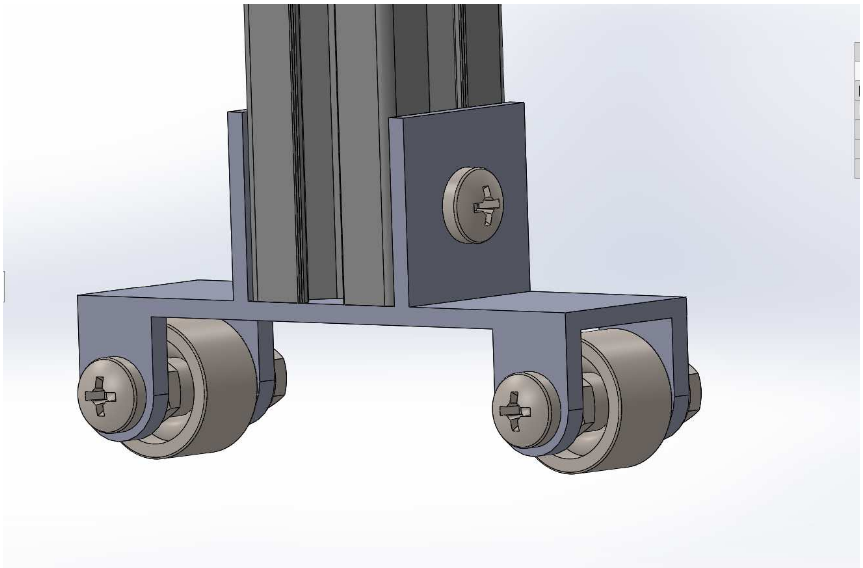

Figure 9. Roller-leg

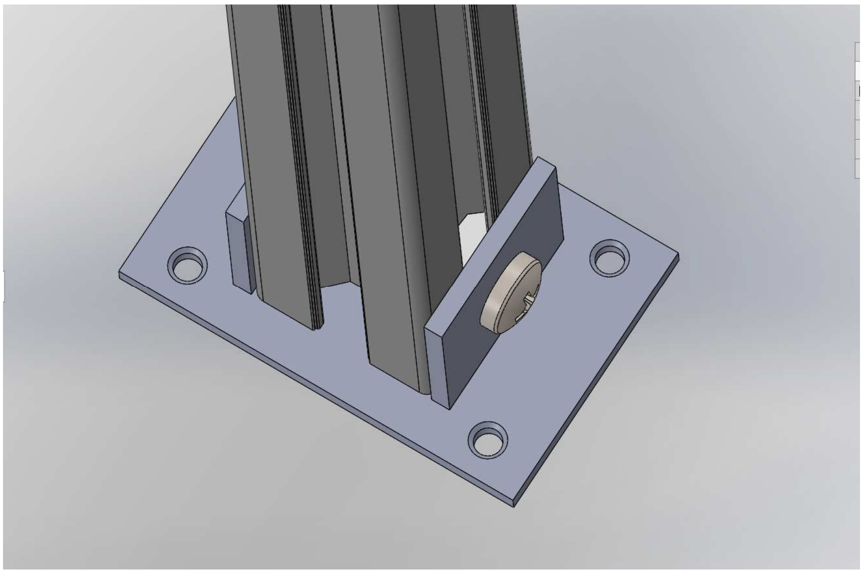

Figure 10. Frame-runner block fastening leg

Above are the fastening plates for connection vertical carrying bars to base bars. On the left picture, there is a construction responsible for rolling motion along the base bar. It is made of aluminum plates with help of bending, drilling, sawing and grinding. The wheels for the left leg are performed by bearings, the axis is the bolts treated through the drilled holes and fixed with nuts. Plates are connected to the bars with the help of T-nuts and bolts.

4.3 Z-axis or the base part

Figure 11. Z-axis right base assembly

The image illustrates the base bar, which provides a Z-axis linear degree of freedom. The leveling feet are a perfect solution for installing the station at a new place, where the surface of the floor might be quite rough. Fastening of the motor and runner block on the rail is standard and is similar to the other axis's. The only two differences are the overall size due to the bigger size of the bar and a 90-degree bent part of the plate to connect the bar to the foot bar. From one-foot bar to another there is a stretched rod for the hooks of the wiring system. In real life, it could be changed with a rope.

Figure 12. Z-axis left base assembly

This figure illustrates the left base bar which does not require the driving function. It has the same feet as the opposite part and the same connections. But the surface is flat for the width tolerance of motion of the left main frame leg, so it is perfect for the contact with the wheels.

4.4 Picture of the whole structure

Figure 13. Complete assembly

The figure above shows the overall result of the modelling process. All the parts listed before are assembled together here.

4.5 Designed parts

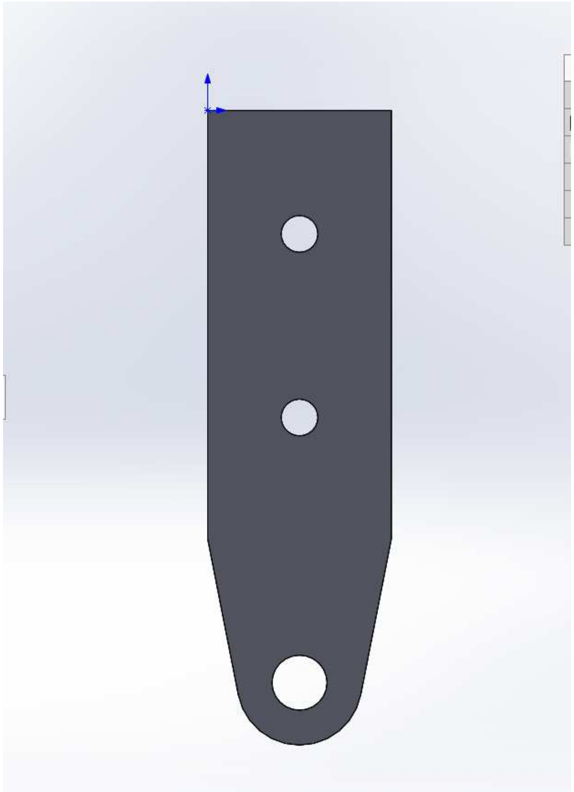

Figure 14. Side pulley fastener 30 mm

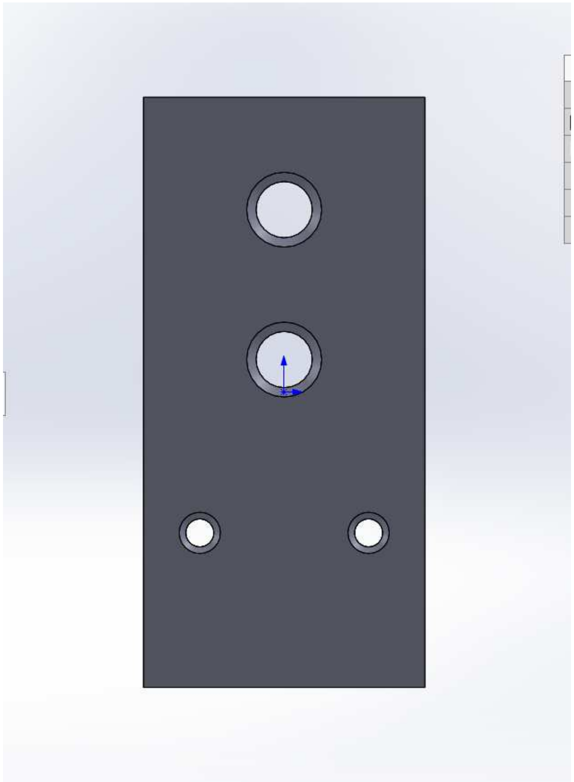

Figure 15. Motor fixing plate

The upper figure illustrates the plate which is used in most cases of fastening the pulleys for 30 mm bars. It has two 7 mm holes for connection to the bar and one 9 mm hole for an M8 bolt.

The lower figure illustrates the plate which is used to fasten the motors to the 30 mm bars. It has two 7 mm holes for connection to the bar and two 3mm holes for fastening the motor.

All the plates of this type are made of 3 mm aluminium sheet. The motor fixing plate is the same for a 40 mm bar except for the width which is, in that case, is 40 mm.

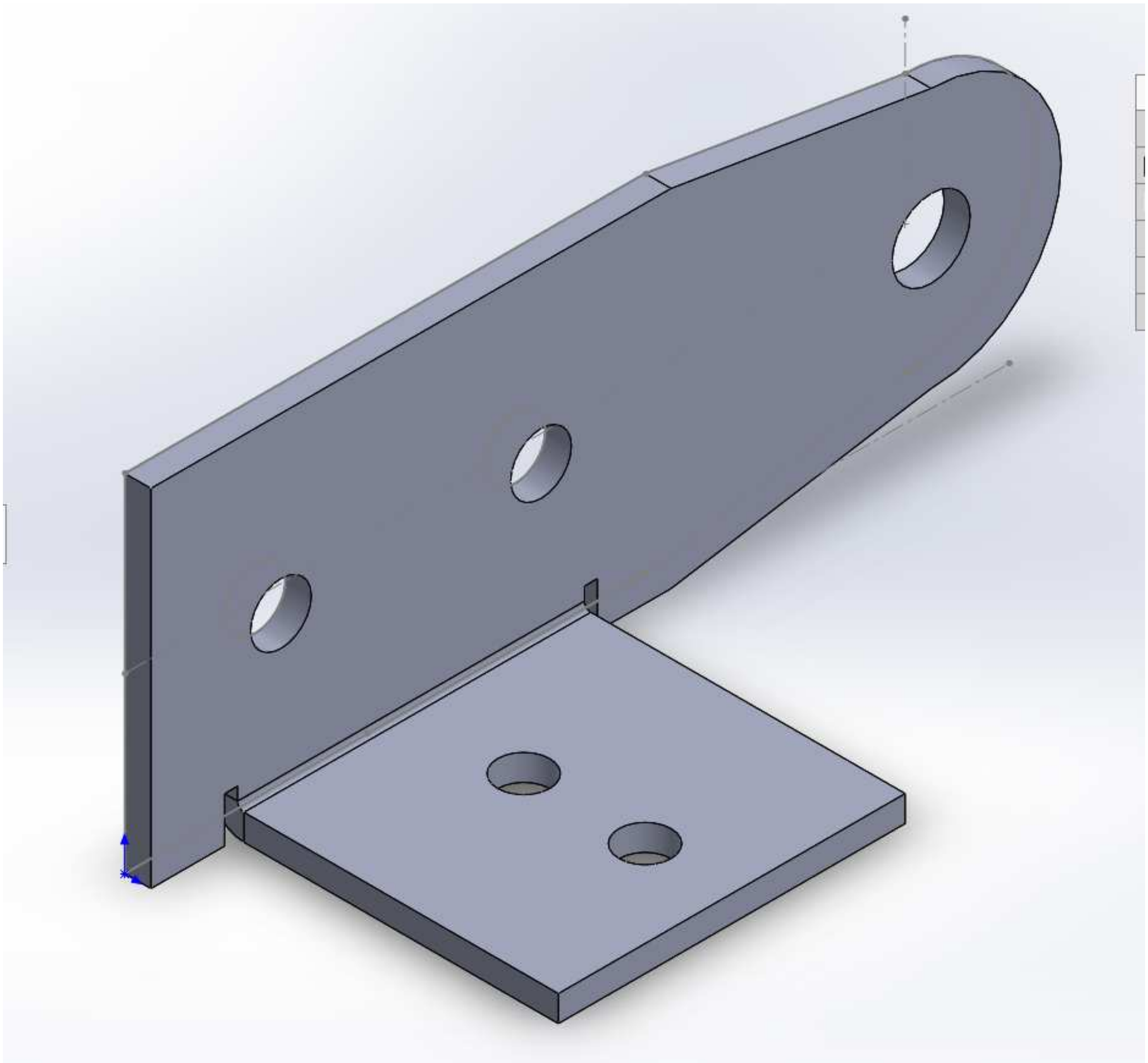

Figure 16. Side pulley fixing plate for the base part

The figure above shows the plate which is used for base parts to fasten the pulleys and leg parts to the 40 mm bars. It has four 7 mm holes for connection to the bar and one 9 mm hole for an M8 bolt.

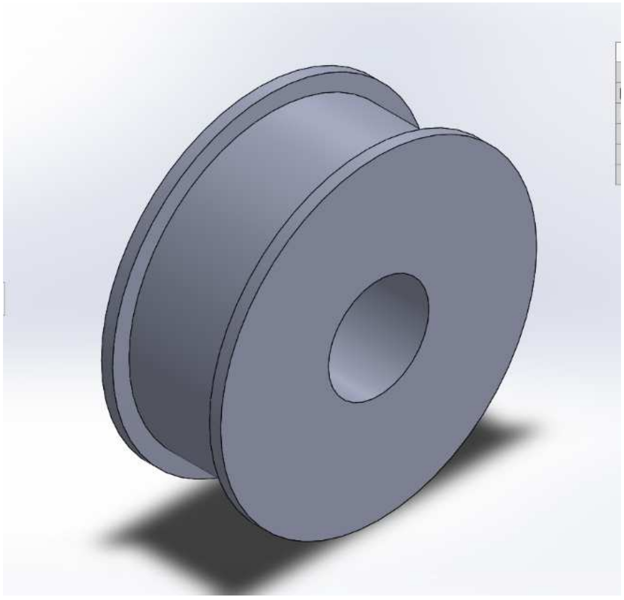

Figure 17. Simple pulley

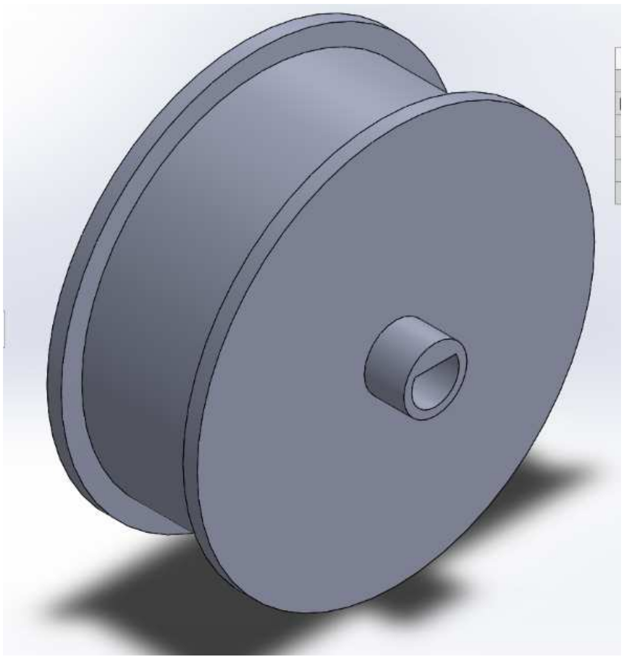

Figure 18. Drive pulley

The figures above demonstrate the pulleys for both the motor side and the opposite side of the Y-axis bar. The upper pulley is simply the wheel with a hole and borders on the sides to prevent moving the belt away from the pulley. The hole in the centre could be filled with a bearing for smoother rotational motion.

The lower pulley is similar except the orifice for the motor shaft. Nevertheless, it has the hole for a small bearing to fix the pulley from the other side.

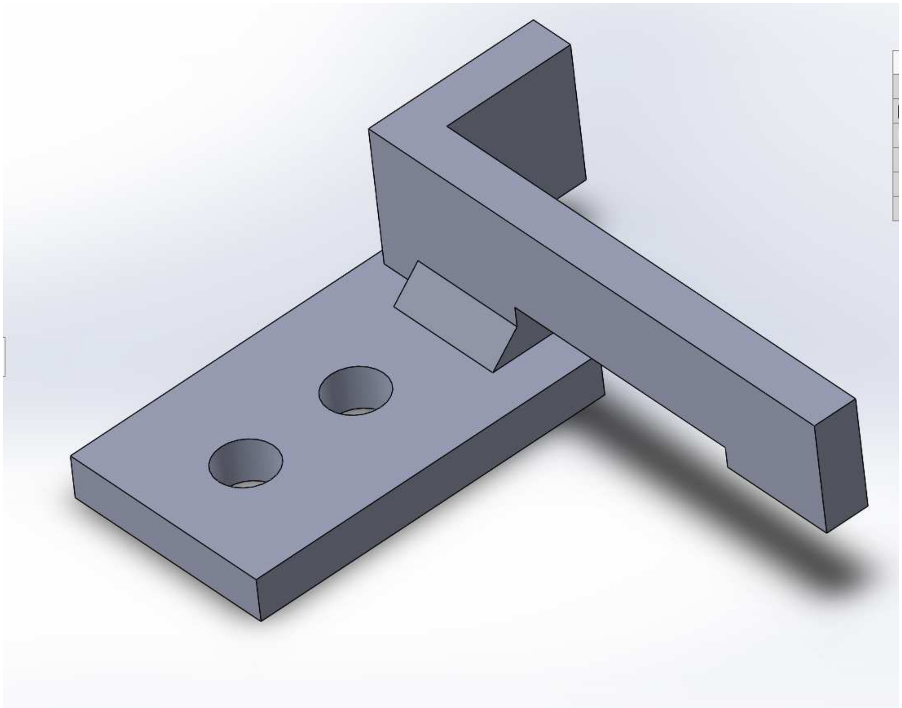

Figure 19. Y-axis belt fixing plate

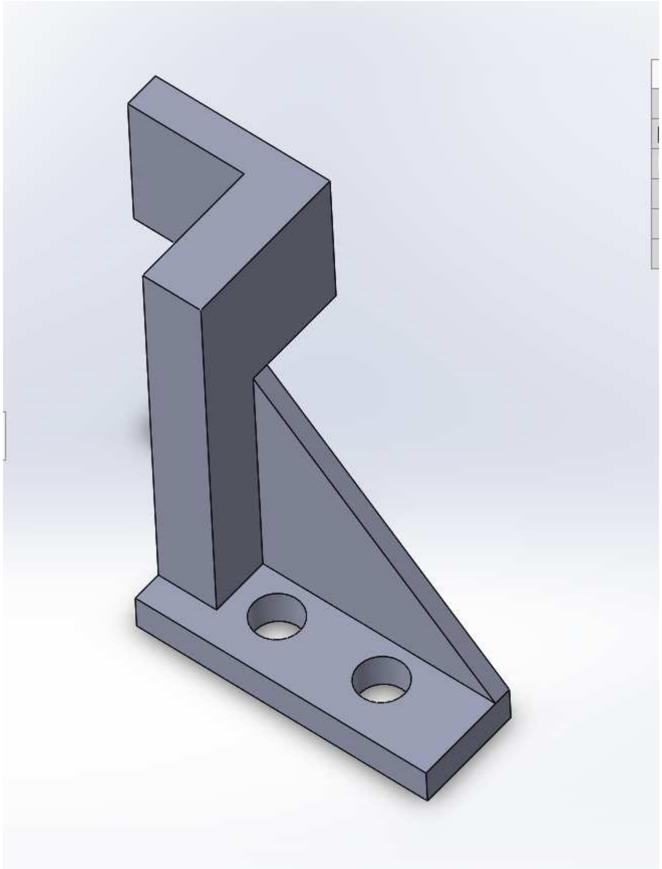

Figure 20. Z-axis belt fixing plate

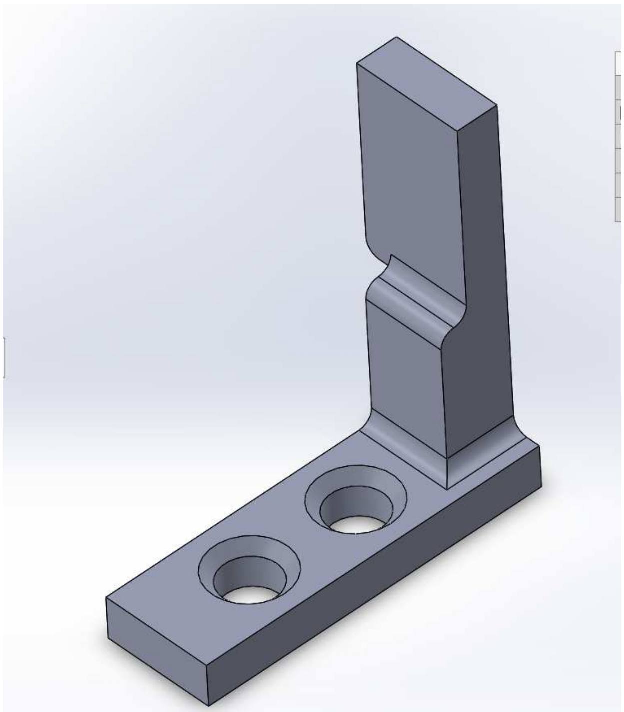

Figure 21. X-axis belt fixing plate

The three images above are presenting the parts which are used to connect the belt to runner blocks. The first two of them counting from the above side are used for Z and Y-axis bars respectively. Their lower part has a 15 mm width, while the part on the right picture has only 10 mm. All the holes have a diameter of 3 mm to fit M2.5 screws. Due to the extra-large height, the part in the middle has a strengthening rib.

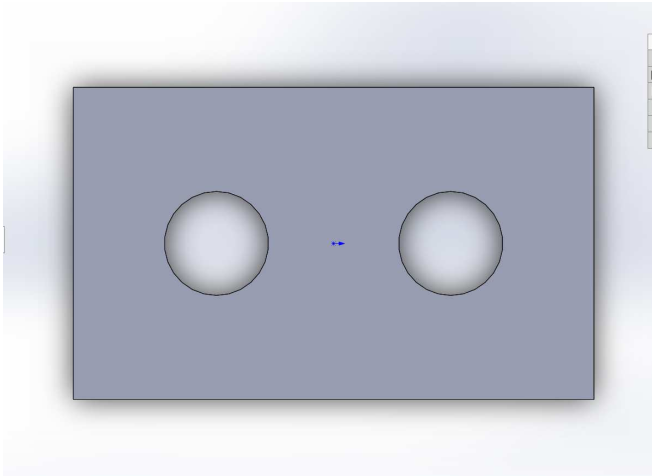

Figure 22. Under belt threaded fixing plate

This simple figure above is a tiny plate with threaded M2.5 holes to fix the belt to the upper fixing pats from the opposite side with the help of screws.

4.6 Options for purchase

https://www.amazon.com/Speed-Geared-Reducer-Motor-Robot/dp/B01FF85U7Y?th=1 – 12V DC motor

https://www.boschrexroth.com/en/xc/products/product-groups/assembly-technology/topics/aluminum-profiles-solutions-components/index - Bosch Rexroth Aluminum profiles

https://www.boschrexroth.com/en/us/products/product-groups/linear-motion-technology/topics/profiled-rail-systems/ball-rail-systems/index - Bosch Rexroth ball rail systems

https://www.norelem.fr/fr/en/Products/THE-BIG-GREEN-BOOK/norelem-measures-Measuring-and-testing-components/31000-Inspection-tables-Gauge-stands-Gauge-joints/31100-Gauge-holders-articulated-armwith-central-hydraulic-lock.html - Articulated arm with central hydraulic lock

https://www.reprap-3d-printer.com/product/1234568667-t5-timing-belt-15mm-width-per-meter - belt 15mm width

http://3dmodularsystems.com/en/linear-motion/399-gt2-belt-2mm-pitch-10mm-wide-sold-by-linear-meter.html - belt 10mm width

5 Summary

Analyzing all the work that was done, it results in a ready to build a model. The whole designing process went smoothly. Every time when a controversial moment appeared, a consultation with the consumer and supervisor was arranged. All the meetings were productive thankfully to the suitable timetable which meant enough questions to appear between appointments but did not mean the work to stop because of too much obscurity.

The model itself could be characterized as successful. The goals were reached, general requirements fulfilled. It can be disassembled and then assembled at a different location. For this purpose, all the details were selected as the lightest of the possible options. The chosen motor is perfect for smooth and slow-motion to achieve high stability and avoid any shakes. The articulated arm provides various angles of scanner positioning options.

The only goal that was not reached was multiple variations of possible sizes of the structure. The reason was that the driving method that was chosen was based on belt motion. Nevertheless, it is possible to have several variations of structure sizes if extra belts and bars gathered, but still, it would be quite problematic due to multiple parts that had to be removed.

6 Figures

7 References

1. Artec scanners brochure. Page 9.

2. https://www13.boschrexroth-us.com/partstream/Load_Category.aspx?category=Aluminum%20Framing&menu=1,0,0 – source of Bosch Rexroth CAD models

3. https://grabcad.com/library/ts-32gz370-5300-geared-dc-motor-6v-1-rpm-37-5-kg-cm-1 - source of used motor CAD model