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Satakunnan ammattikorkeakoulu  
Satakunta University of Applied Sciences

DIONYSSIOS RAPHAEL KOUTSIS

# **Mechanical Compound Robotic Tool**

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## ABSTRACT

Dionyssios Koutsis: Mechanical Compound Robotic Tool

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Mechatronics Engineering

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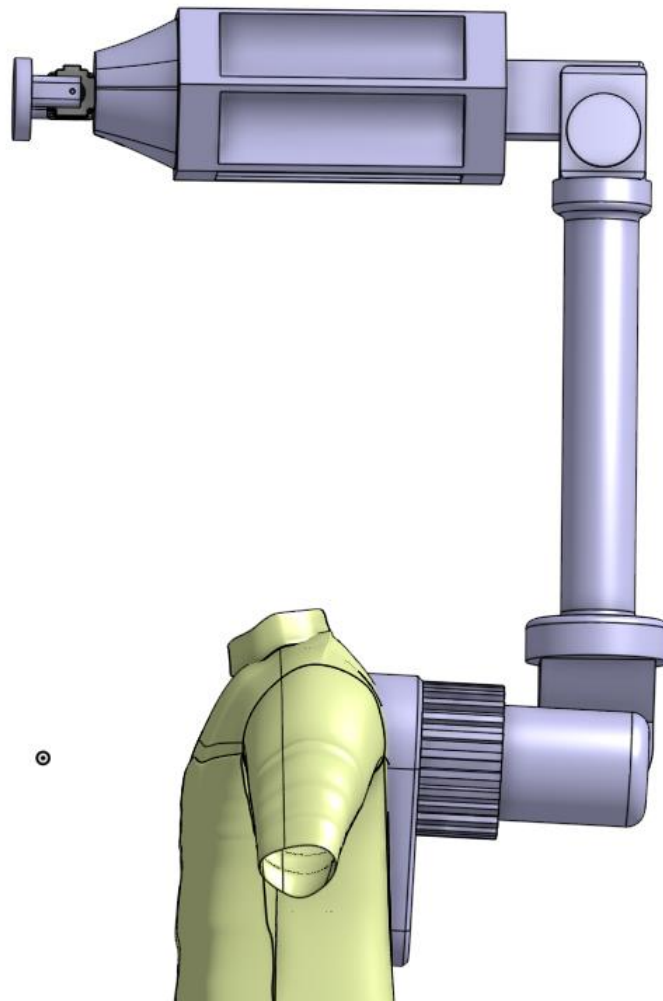
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In the workplace of an Engineer, we can always see in the surroundings a multitude of tools and machinery in which exist in a singular tasked form. From Soldering pens, plasma Cutters, welding machines, and of course tools in which we need when working in metallurgy, making the process of an engineer feasible. Collaborative robots have been also introduced making automated process or precise collaboration between worker and Robot, turning the work process more efficient and faster, thus more productive. Robotic arms or automated machines have been also limited in tasks, as they are either stationary or have an automated controlled path. This idea can be improved, making it even faster, more efficient in the workplace.

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## 1 INTRODUCTION



*Figure 1: Side view of the MCRT Made in Onshape 3D design*

The present technology of our everyday life now has improved our everyday labours. From gardening, metallurgy, construction, electrical emplacements, all stem from tools and hardware devices we keep in a spare tool case. After having worked with Robotic mechanical Arms that we used for welding and tireless labour. Working on repeated tasks that either require strength or precise and accurate movements without flaw, the answer to taking a step further towards effective productivity is simple, combining the tools we have in hand into one. Through design and brainstorming the pros and cons of this idea, working on this hardware device that would facilitate the work of labour, turning

it into a tireless outcome that would have needed twice the workload. Companies that came up with exoskeleton tools and collaborative robots only aimed to solve the problem of one type of labour, payload (COMAU, n.d.)(figure 2). But in many fields where physical work is needed, strength is not the main attribute to work towards. A collaborative robot is a great solution but, they are not mobile, the Mechanical Compound Robotic Tool is much more than just a mechanical arm, it is a lifeline helping the user head towards effective productivity and safety.



*Figure 2: Robotic exoskeletons Suits, (COMAU, n.d.)*

## 2 THE VISION

I will clarify the many uses of this concept idea through the work of my thesis, showcasing my designs, the different hardware and software that are designed to be in use. As to finalize a product in which would essentially be an assisting robot sitting over you. In quite the literal sense the Robot would be emplaced on a mount off a vest in which the user will be wearing. The position would be over the upper back as the weight of a robotic arm envisioned to be around 15-20 kg, would need to be placed on the upper side muscles just above the middle of the back. That placement would be more beneficial for the mobility of the MCRT's as well as having more space to keep the user out of collision with the tool.

The main feature of the machine is to be able to have a collaborative robot composed of a multitude of tools encased in it, being able to change by given commands of the user. The sensors and hardware as well as its interface and

software would also assist in different works. From protecting the user from harm when working with the plasma cutter tip or scanning a surface of a wall for safe spot to drill, locate pipes or electrical circuits with an ultra-sonic vibration sensor.

The more I dived into the details of what the MCRT would need to achieve safety as much as being compatible with a lot of fields of work. The main solution was to not change the hardware but the utilities the MCRT will be composed of. Before diving into the details of the hardware and intended software as well as the tools, the concept activity and work of the MCRT on every field will be showcased.

## 2.1 Engineering/Metallurgy

Starting from the initial idea where the concept was meant for, the field of engineering and work surrounding metal, working with impact drills, saws, soldering etc.... When working with material that requires bigger machinery to render malleable, these machines require a given space as well as a professional. Even collaborative robots who have been modified to be able to work with welding, soldering or plasma cutting, have their limitations as accessibility to a different area is a challenge.

Working in the MCRT concept, I wanted to make the physical and process of a project easier and more efficient. Having the capacity to have a multitude of metallurgy tools with the help of a remote-controlled machine that is situated at a close range will also accordingly, have the equal amount of safety precautions. Considering the energy consumption of the machinery, the MCRT will have the possibility of connecting to a power source completely, thus taking away the need of the portable battery, situated on the back of the vest between your shoulder blades (will go in further details on later section).

In these two fields, the biggest problems are maintaining safety and equipment malfunction. The MCRT is envisioned to ensure the safety of the material and tools as-well as the user's. The expected outcome of the MCRT on top of having a software to be able to control manually the robot as well as changing the tools with one command, is to having an AI assistant to be able to work with the user without overstepping, unless the safety of the user and then the MCRT's are in danger. Ensuring that while working with equipment that require rigour (plasma-cutter attachment, Welding/ soldering tip, drills), the MCRT's AI can recognize through visual and proximity sensors (using a supervised machine learning model), to know when and how to take precautions against danger. That danger can come from human-error or environmental, being able to recover the user from a certain fall from a ladder or a scaffold, or stopping motion when the soldering equipment might damage the nearby tips.

## 2.2 Environment and Infrastructure

Physical work with today's technological advantages takes onto a different level when working with tedious tasks alike: electrical circuits in tough areas to work around manually, irrigation installations, landscaping, roofing, or framing. These tasks are performed with the specialized tools on hand, and most tasks require physical work. Physical tasks do not come without effort and in many cases uncomfortable positions and movements can cause discomfort or injuries. Framing a door, where holding the material of the frame while simultaneously using the nail gun or a similar task, can be a tiring to perform persistently. Using the MCRT as a spare limb to scan the frame area using the 3D lidar, can then send the measurements to the controller-phone. This can be useful for cutting or sanding the material with the MCRT's tools in case of adjustment and then helping you clamp the material showing which placement would need a clamp, and then choosing either manually or through recommendation from the AI assistant, the nail-gun placements.

Working on a heavy workload construction site can also create bodily damage. If a wrong movement is performed, taking away from the worker the trouble to

bend over backwards to fix electrical circuits or connecting pipes with welding equipment, can greatly increase the efficiency, productivity and mental being of the professionals.

The concept of having the MCRT as a safety assistant, as-well as a compound tool-case, will better the lives of many people, taking away the risk from the “risk job” while not taking away the job from the professionals, only assisting. Using the safety equipment within the MCRT for example: proximity, vibration, lidar, ultrasonic, electromagnetic sensors can evade unnecessary damage before it is too late. With the help of the DC motors (review later paragraphs) and a corrective algorithm, the compound will be able to regulate its balance protecting the user from heavy material or unbalance.

In a worst-case scenario, where the MCRT has not precalculated accidents alike falling of a scaffold, the robot will utilize its own mass to stabilize the fall and minimize damage. Protecting the user from falling material or branches is also was the robot will be capable of, ensuring safety in all environments, keeping you in top condition to work as efficiently as possible.

### 3 COMPARABLE PRODUCTS

Taking example throughout the many collaborative robots, the capital problem solver of each product is to render a task easier. Either by implementing an easy-to-use programming interface, an artificial system to make the integration of the Cobot into various engineering tasks easier (metallurgy, material handling, quality inspection, machine tending). The Universal Robots (UR) were made to be able to be used without experience in the field of robotics opening the door for possible use in many fields where the Cobot would shine. Unfortunately, not many Cobot were made to be movable and maintain the flexibility of usage with a user, reviewing the different products that can, end up being driven by AI and machine learning algorithms (Universal Robots, n.d.). Making a robot fully automated takes out the work that can be done with humans, taking away from tasks that are meaningless for humans to perform manually.

The MCRT is envisioned to take the similarities in the user-friendly programming of the interface as to provide a customisable profile for every user based on their activities. This custom profile would change based on the tools inserted in it, meaning every custom tool will have its own private key to get recognized by the system. When recognized the system would change to the relative movement it can perform with the selected tool, some tools would need different movement patterns for example: welding tips cannot be moved as fast as a drill tip or too close to the user, gripper have a different manoeuvrable speed and motor control as more hardware is introduced.

Another advantage the MCRT would have been managing to have a 10-20kg payload with a 1-meter reach based off its position. Compared to the UR16, the UR can reach up to 900mm with a 16kg payload, while the payload is great the stationary reach will limit it to one position (UNIVERSAL ROBOTS, n.d.). Alike the MCRT it can be used in the same industries, including automotive, electronics, consumer good and metallurgy, but if not converted to an automated moving machine its tasks will be area-restricted.

#### 4 MCRT COMPOSITION / HARDWARE

Just as many collaborative hardware taken from multiple examples, such as ABB (Moseman, 2025). The motor, gearboxes, sensor, operating/programming environment, and structural material are very similar as the MCRT will be a collaborative tool with somewhat similar movement and activity, in this section all the specified components will be given based on schematic patents.

The MCRT will be composed of three structures connected by servo motors and mechanical joints, as to provide a base moving over the shoulder or under of the user, as well as a an “arm” made in two sections in which the fore arm section will hold up to six tools.

## 4.1 Wrist/stump



*Figure 3: Nema DC brushless motors, (INC., n.d.)*

The motors are the stepping stone of the robotic hardware to move with swiftness, accuracy, and delicacy. If the movements are not smooth and articulate enough, the user and objective may get in harm's way. That is why a brushless DC servo motor will be used for the joint movement as to never underperform in high precision actions (plasma cutting, welding, soldering, work on the millimetre scale etc...). The MCRT is envisioned to possess two smaller brushless motors in the "wrist area" as to provide a x and y axis wrist movement placed perpendicularly (INC., n.d.)(figure 3). This is to give a wide range of motion for the tool to have for it to keep a high accuracy when working no intricate movements. The clamping mechanism would be corresponding of the tool; each tool would need different amount of pressure in clamp based on its utility. The end stump would be made of 316 steel alloy to avoid corrosion around water and salt water, as well as high temperature that can occur in welding jobs or drilling/cutting dense metals (John, 2024). The tool would then clamp over the extremity of the stump that would be of bigger diameter than the core as to camp over the 2cm thick steel for greater support. On the base of the stump's

2cm disk, a high retention type B USB (figure 4) would be put in the base for the tool to connect directly when connecting, as well as a high-pressure resistance tube opening for gas use or high-pressure airflow for tools (SAMTEC, n.d.) (McMaster-CARR, n.d.). As for the tools made to withstand direct hit, they will be coated with Inconel 601 alloy as it can take salt water and high temperatures of 2,200°F (1,204°C) (High Temp Metals, 2015). The coating of the MCRT would be of 316 SAE steel, as it is marine grade steel able to work in all kinds of harsh environments, in which would fulfil the purpose of the MCRT. From the sea, to high humidity, to the highest of temperatures, all professionals in all kind of working environments would be able to benefit of 100% usage and support of the MCRT (John, 2024).

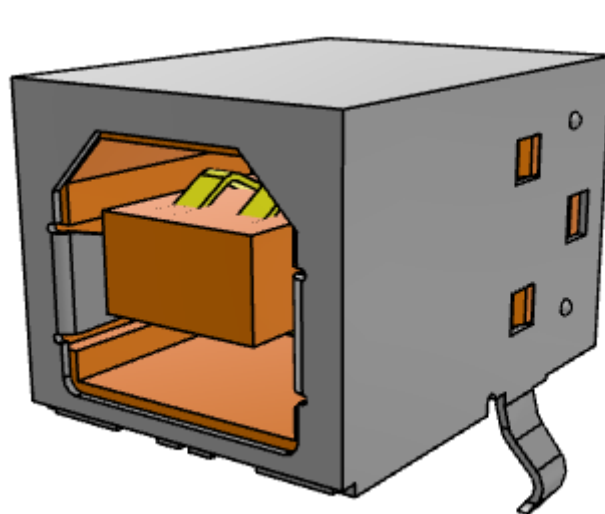


Figure 4 USBR high retention (SAMTEC, n.d.)

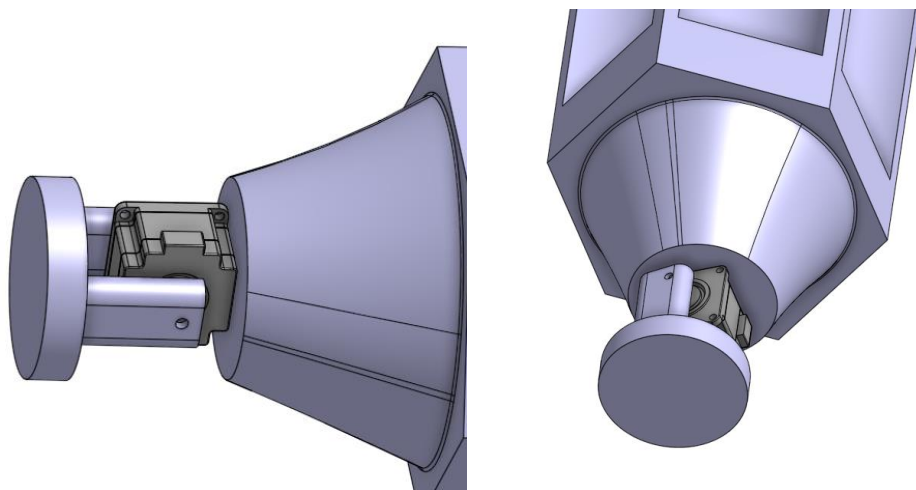


Figure 5: Wrist/ Stump 3D representation on Onshape

## 4.2 Fore-Arm / Upper link storage



Figure 6: Brushless motor for the sprag clutch (T-MOTOR, n.d.)

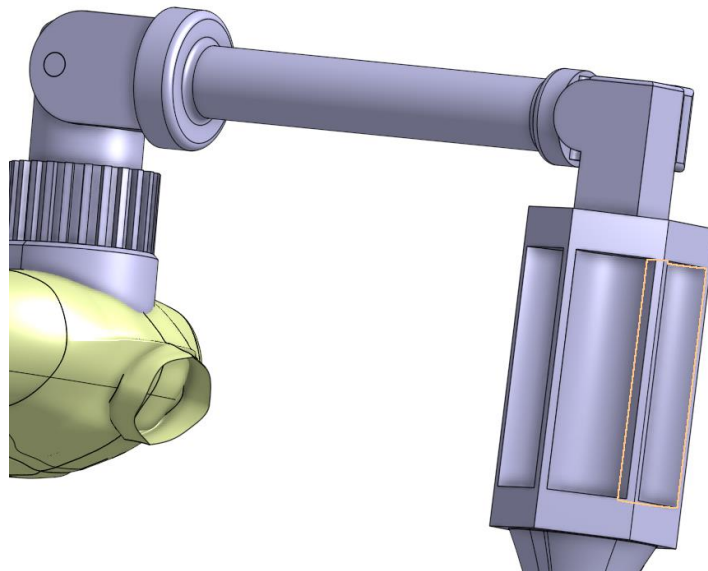


Figure 7: Lower/base and higher Link with Tools Storage view

When designing the storage “forearm,” the most efficient geometrical shape relating to the material of the tool (aluminium skeleton) would be a hexagonal

shape, being able to host up to 6 different tools. The projected design for the forearm aims to be able to not only host tools but using its elongated form of around 40-50cm to increase the working radius of the MCRT. Using a continuous motor with an axle, the forearm storage will be in between the lower link, and the wrist where the tools will be connecting. The forearm will be covering the axle completely as to be able to rotate upon itself without affecting the robot's position. At the base of the wrist a brushless motor would be connected to the inner face of the sprag clutch and the continuous rotational face on the outer (T-MOTOR, n.d.)(figure 6). The forearm would move on the side that would not engage the sprag clutch (figure 8), for it would be easier to grab and insert on the stump manually (HVH industrial). The movement would be recognized by the interface of the MCRT, giving the user the ability to manually choose the tool while also having the system recognizing which tool is being chosen. Facilitating the MCRT's manoeuvrability in between storage and usage of tools, a PTFE (Polytetrafluoroethylene) casing will be covering the inside of every six chambers. With non-stick properties, high melting point and chemical resistance, PTFE is a perfect coating material for a low friction storage compartment as well as when the tools need to be taken out. The storage themselves would have a mechanical spring lock that when pressed, four hook claws covered in PTFE would clamp the tool, safeguarding it from falling out (Sewport Support Team, 2025). This would come easier for the user to grab and place on the stump easily with the help guide, as well as manually opening and closing the clamps for better safety features. On the base of the fore-arm where it would connect to the lower link skeleton, would be connected with two smaller brushless servo motors for x and y axis, although smaller and weaker

than the two motors on the base yet detrimental for better articulate movement, stability, and precision (Linengineering, n.d.).

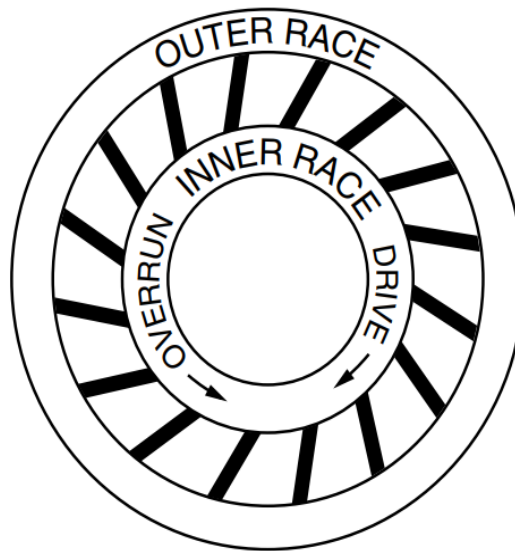


Figure 8: sprag clutch mechanism, (HVH industrial)

#### 4.3 Base / embedded system



Figure 9: ABB lithium Thionyl Chloride battery, (ABB, n.d.)

The computing interface would be inside the foundation base of the MCRT as well as the battery (figure: 9) (ABB, n.d.). The battery being in between the user inside the ventilated vest and on top an aluminium sheet, this would facilitate the energy source integration with the NXP/Freescale kinetis, a DSP (digital signal processor). The reality with using a lot of real time sensor, means

that you need real time digital signal processors, this microcontroller would be able to process all the different sensors as well as being able to hold the machine learning program and the different program conditions. With up to 2mb ram and the ESP8266, the interaction and commands will have enough memory servicing using UART in which the Kinetis K66 supports (ELECROW, n.d.)(figure 10).



Figure 10: Arm Cortex Kinetis K66 180 board, (NXP)



Figure 11: base DC brushless Motors, (Allied Motion, n.d.)

On the base two large dc motors will be place as to engage the “shoulder” motion x and y, with the force capacity to withstand 15kg, the base itself will connect to the lower link, that said link would be a hollow three aluminium pillar to maximize weight efficiency as well as structural integrity(figure 11) (NXP, n.d.) (Allied Motion, n.d.)(figure 12).



Figure 12: ESP8266 IOT board with Wi-Fi module, (ELECROW, n.d.)

#### 4.4 Microcontroller

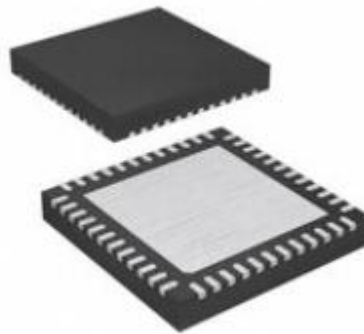


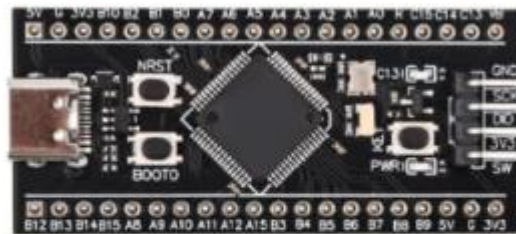
Figure 13: NRF52832 module representation, (Nordic Semiconductor, n.d.)

The idea based upon the microcontroller would be example of a hand-held gaming console, as having a portable device with many integrated features would make the tool usage safer as the user will not be using their own hands for work as much, as well as giving a more controlled feeling of the MCRT.

To maintain a good integrity for the control of the MCRT, the microcontroller would be fully integrated with enough hardware to keep the user grounded with the tool in use. Using a nRF52832 Bluetooth 5.4 transceivers and audio streamer (Nordic Semiconductor, n.d.)(figure 13). Is a high-performance single chip able to connect wirelessly to almost any device. With advanced Bluetooth LE features, the controller will be able to respond with high precision and time (high speed 2Mbps) for a low energy consumption and very low latency. As

processing power for the MCRT the STM32F4 ARM cortex-M series is perfect for high performance while maintaining low power consumption as well as wide range of peripherals, being able to handle complex data coming through the controller (STMicroelectronics, 2025). Specifically, the usage of the STM32F01 Black, as the 84Mhz clock speed and the architecture of the M4 will prove beneficial for the real-time sensor command input and output towards the microcontroller. The microcontroller although responsive through JavaScript for the interface compatibility with the user, will be able to send and receive command and data information with C++ or C#. (STMicroelectronics, 2025)(figure 14).

## STM32F401 BLACK PILL



- ▶ **STM32F401CCU6 ARM M4 84MHZ**
- ▶ **FLASH 256KB SRAM 64 KB**
- ▶ **USB OTG, USART, I2C, SPI, ADC, DAC**

Figure 14: SSTM32F401 Black Pill, (STMicro Robotics, 2025)

Wanting to make the interaction with the MCRT as haptic as possible, the controller will be equipped with a haptic feedback motor, working in different frequencies for different tools based on the pressure of one tool, when for example exerting on an object. This will change for every tool as to give a better feel to the user through nuanced vibrations, as in the case of error the motors will make patterned vibration to give a quicker response for the user as well as the precautions taken by the machine learning algorithm (Adafruit, n.d.)(figure 15).

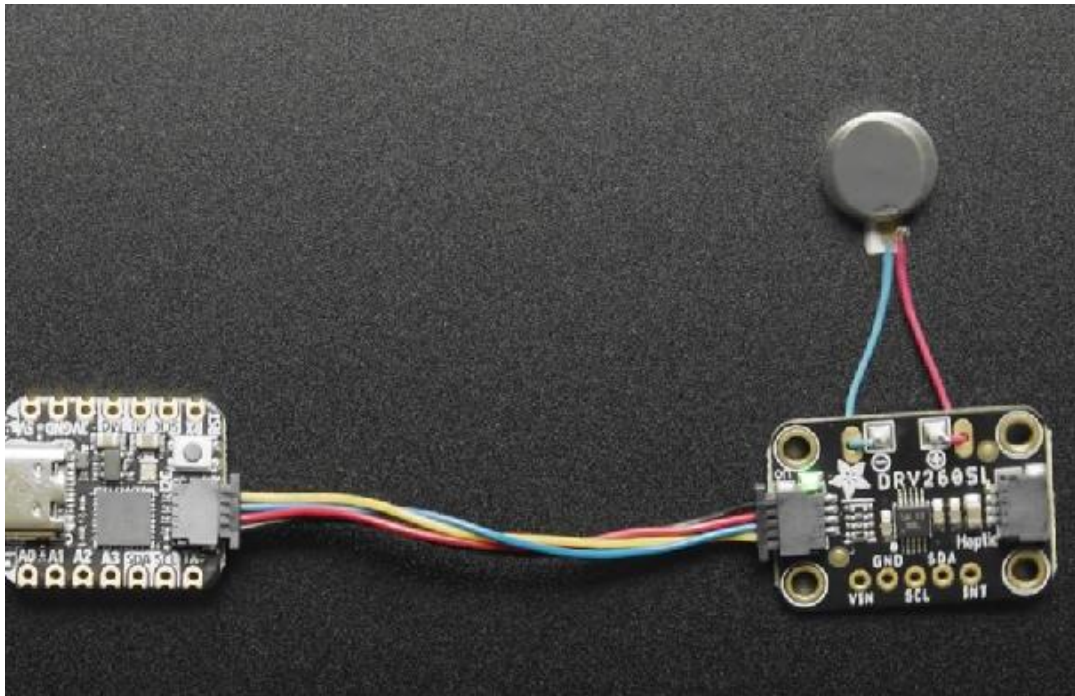


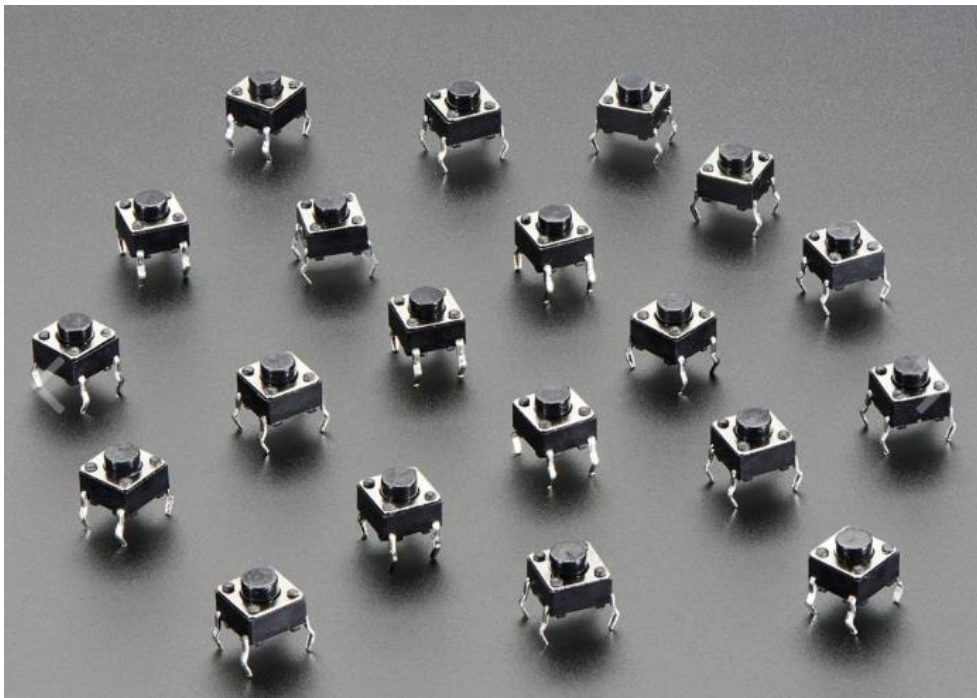
Figure 15 Adafruit haptic motor and controller, (Adafruit, n.d.)

As to be able to manually control the different tools (analysed in a later section), the controller will be equipped with dual Analog sticks that use potentiometers to detect accurate input to then translate into movement for the tools (newegg, n.d.). In their corresponding side under the Analog-sticks, two cross-directional D-pad buttons will be there to be as a slowed reading input for more precise movement, directional or metric input (figure 16).



Figure 16: 3D Analog joystick module with potentiometer, (newegg, n.d.)

With 6 smaller circular buttons to be assigned short-cut or custom commands, each side would be complete. Turning in the back, a strap attached from the top right loops down to the bottom right around the right hand for better handling and safety of hardware (figure 17). On the top left and right two bigger buttons are perched inclining fitting the index, their role would be to confirm actions with tools for example, the left would be for movement and right for activation of tool (saw, welding, solder, open/close, I/O) (Adafruit, 2025).



*Figure 17: 20 6mm tactile buttons, (Adafruit, 2025)*

These attachments input buttons and analog hardware will be installed on a ESP8266 IOT board equipped with a built in ESP-12E WIFI module as to be able to be programmed through PlatformIO and then connected through a web server (built in support using a socket or webrepl module of the PlatformIO environment) which then would send commands directly to the STM of the MCRT (STMicroelectronics, 2025) (ELECROW, n.d.) (wh\_hsn, 2015).

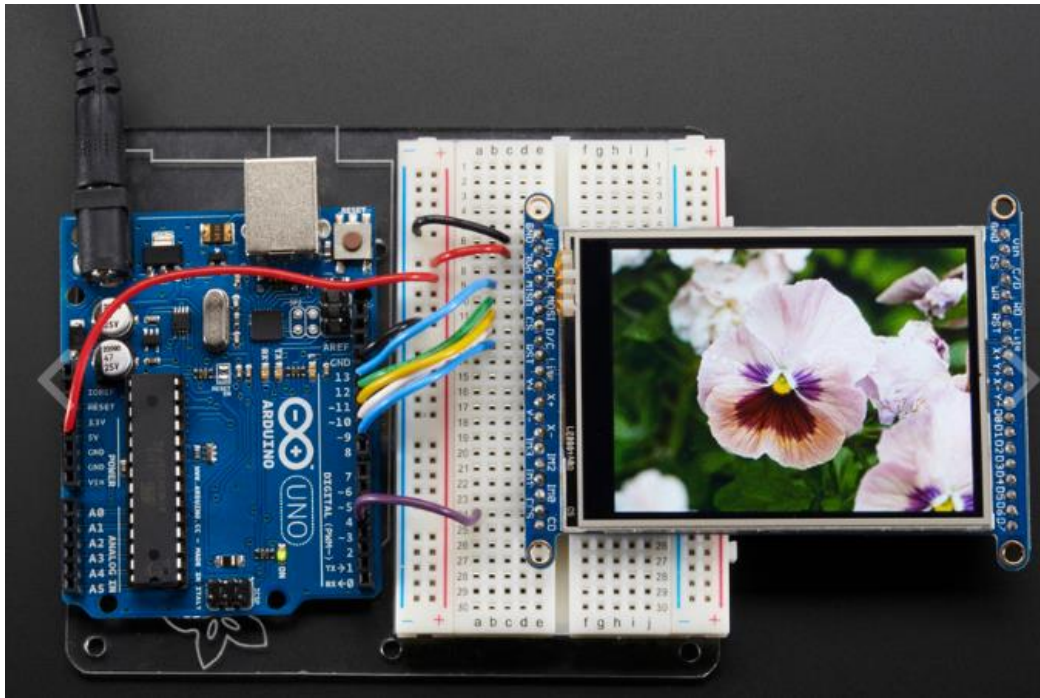


Figure 18: 2.8" TFT LCD Touch screen, visual screen for the microcontroller, (Adafruit, 2025)

#### 4.5 Sensors

AI assistance is one of the most useful tools to be used with every day technology that can be too complex to be manually controlled. A lot of hardware used by professional in all field come with prewritten shortcuts that take out the manual control of the machinery as to limit error as well as time consumption. Just as the same, the MCRT will be able to be controlled fully by the controller/pendant, from movements and tool control, to program selection, custom commands assigned to specific buttons to potentially make certain transition between actions easier and more efficient. Of course, safety cannot be always monitored by the user when they are in the middle of their work, that is why it would be beneficial to program a machine learning algorithm that could make sure the safety of the user as well of the MCRT are guaranteed. The MCRT will possess a precisely chosen types of sensors for that will not only play a role in safety but also the quality of work of the tool. To start off, the base of the wrist in which every tool will be attached, the placement of a force and torque sensor must be integrated right on the locking area (“stump”) where

the tools attach (Shlenkent Entreprises). Without a way to measure the magnitude and direction of the force the MCRT will be exerting, it would not be able to respond effectively to collision with object or even the user (figure 19).



*Figure 19: dual-Range Sensor with brushless Transmission, (Shlenkent Entreprises)*

Before attaining collision and avoiding harm, envisioned proximity sensor on the base behind the back of the user, the fore-arm, and the wrist. Depending on the tools and if they interact with light, an infrared sensor will be equipped within some tools, but ultrasonic sensor could be the main three sensors for the three parts mentioned above. Ultrasonic have their limitations as they only recognize distance but not what the object in their vicinity are, they are efficient because the information travels fast as well as calculating speed, potentially signalling the robot to move slower, halt or move away from collision while making sure the user is safe.

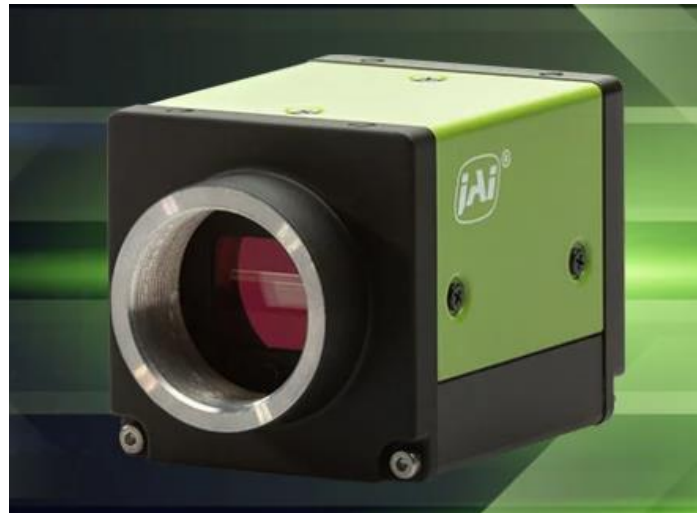


Figure 20: Bilinear and monochrome 4096-pixel(4k), (JAI, 2025)

For the MCRT to be able to recognise imaging, two different small industrial vision cameras perfect for heat and vibration shock resistant and one fish eye camera would be in the base top part of the fore arm, in parallel on the underside and one on the base of the wrist (or integrated with specific tools that require magnifying features for more intricate work)(figure 20) (JAI, 2025) (HiTechChain, 2025).

Paired up with a machine learning algorithm, the MCRT will be able to recognize objects and detect the presence of the user . That could achieve a greater efficiency in work with the potential of recognizing past projects and trajectory movements as to be able to correct any future collision or send suggestions for different paths or actions directly to the controller, for the user to consider. Unfortunately, the capacity given to the compound tool can only be visual and thus cannot feel or detect potential environmental shock that can be hazardous for the user at hand. The application of a temperature and humidity sensor could greatly increase the safety protocols to be taken by the MCRT as to preserve its own safety but as well as us (Seeed studio, 2025)(figure 21). By placing the temperature and humidity sensor at the end of the forearm closest to the wrist, it may calculate the most efficient area, as the placement would be the most probable position between the user and the high-heat source.

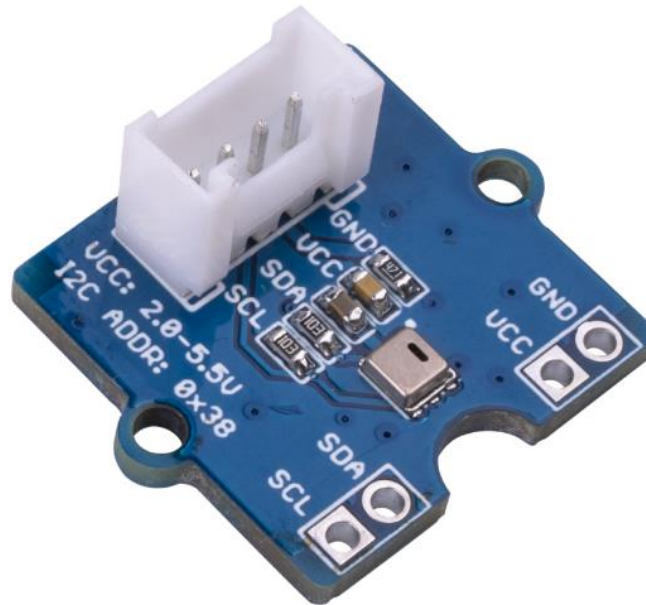


Figure 21: AHT20 I2C Industrial Grade Temperature and Humidity Sensor, (Seeed studio, 2025)

With the machine learning program, a preexisting threshold would be established as to be able to warn the user of a specific proximity, in which the user would know that they would be put to danger if they went closer or brought it closer. The infrared sensor inserted on the fore-arm closest to the lower link, would be able to monitor all 360 angles as the MCRT can then monitor the temperatures of the user and the environment (figure 22).



Figure 22: Infrared Raspberry Pi wide lens camera, (HiTechChain, 2025)

The infrared camera sensor is equipped with a 1080P Sensor Raspberry Pi, meaning it can achieve a very high resolution with 30 fps (figure 18). That can be then scripted into the machine learning program and with the fisheye 160-degree angle camera, it can achieve wide range scans but also up to close range lower resolution with higher frames per second detection of 720p/60fps – 480p/90fps. Of course, the lower resolution might cause problems with the machine learning image detection, which is why the lower resolution would have to be 720p as it can still achieve a fast enough precision with 60fps. That fast frame picture intake would help with many works, for example with the specific prawn tool (will be explained later in detail), it possesses a small camera and another identical infrared camera as on the fore-arm, its use would be of electrical circuitry and equipped with the infrared technology it would be effective against wire or hardware overheat prevention.

#### 4.6 Machine learning program

The foundation for the interface of the MCRT will be the same as every collaborative robot, JavaScript and Linux is the most efficient communicative and interactive in which, being able to create some form of application to interact with the microcontroller would be essential. This would be perfect to apply functions (conditions) as to what the MCRT will be able to do and operate. Before being able to have a ready application/interface, the foundation functions/conditions need to be clear and synergize.

Achieving the level of security in which is expected of the MCRT to recognize ever tools and every sensor, to be able to properly adapt the machine learning model as to have the perfect safety officer, as well as adaptive tool.

The following section will vary with the different conditions that would need to be applied in the machine learning script. These conditions are similar to “if/ if-else commands. Nonetheless they are detrimental to the foundation of the safety and function of the Robotic tool.

The first condition would be to always keep the user and the MCRT safe.

Meaning that the system will try to maintain safety distance by taking data from the multiple sensors a to detect the presence of the user (visual cameras, Li-DAR, infrared sensor, torque sensor). By systematically calling a loop in which the MCRT would draw data from the sensors would ensure a life feedback form the system. When reaching a specific threshold of distance towards the user, the system would know when to stop or movement to make as to avoid dangerous physical contact.

Another helpful condition that can assist the previous would be to be able to recognize through repetition or through inscription, to be able to repeat familiar movements as to avoid over compensation. In the example of a welding and mechanical job, the robot would be able to recognize and act or suggest recommendation for specific movement that may help or minimize extra compensation on the system and the user. In the same example when assembling a specific object onto a surface, if done a second time the MCRT would be able to give a suggestion to automatize the next step when given the command, in which the system will give instruction of user placement depending to the object as to then go "hands free mode" as to let the MCRT take over. After the utility command the user will be in full control, and in the case of a second opinion the user themselves can cancel the command at any time as long as the top will not harm the user and the MCRT (in which fall under condition number 1).

Since the system abides to the absolute decision of the user as long as the first rule has not been broken, the condition is set as long as the system is placed in extreme conditions in which it cannot protect itself after making sure that the user is safe first. It may protect the user in an "all cost" condition. This would be that I using all sensors as to detect where or what the system needs to operate to put the user in safety without the preservation of all hardware integrity.

When inserting the different tools which first would be elected after the MCRT has already placed the precedent tool in the forearm, if the tool has not, I will proceed with equipping the selected tool given by command from the micro-controller.

The tools need to have their own respective "safe area," this area will have their respective measures included in the script to be recognized by the MCRT

either from the back-end program or straight from the live view from the different sensors. This would assist in making sure that the tool does not interfere forcefully with the host or the environment without proper precautions. These precautions will be a condition applied to the MCRT in which movement speed and accuracy will change based on the complexity of the tool. This will vary from micro-grip tools for soldering and electrical engineering jobs, to heavy use tools for hard material like metal, wood, or concrete. Without these precautions and change in adjusted speed, the host may forget to manually change, making the MCRT more user and accessibility friendly.

This condition will be subsequential as when proximity of the environment (towards the project at hand) comes closer to the Tool, the MCRT would suggest a change of speed for better accuracy depending on the tool and project. It is expected from the MCRT to recognise based on the tool the approximate project as to either: 1. Be able to recognize from past projects a similar safety precaution, or 2. An approximate evaluation on the environment based on the tool to provide the simulated safety needed for the user to consider.

## 5 TOOL EXAMPLES AND VISIONED PROSPECT GOAL

This section will be dedicated to explain the broader help of the MCRT in every field envisioned with the example of one tool. Each selected concept tool will play the role of showcasing the potential of the MCRT in making the work of a professional better and more efficient.

### 5.1 Electrical engineering

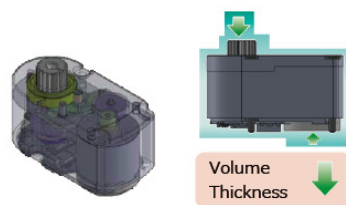
When working with situation with electrical wiring and restrained positions in which the human body cannot always keep in prolonged times, the best way to combat is either taking breaks, or finding a more complicated solution that would require a longer process. In the example of a steep or angled wiring inside a grid machine or just electrical wiring in a building, the MCRT with the

help of the quad-prawns the user is envisioned to be in a comfortable standing or sat position while commanding the compound to lock into the closet position in which the Quad-prawn tool can be able to interact with the wiring while maintaining perfect stability. The MCRT would send a message to the microcontroller to lock position when near enough as to keep the rest of the compound as immobile a possible, with the only movement being moving either closer or further as well as balancing out the occasional movements of the user.

By themselves the quad prawns have the help of 4 small servo motors for a x axis on the base of each prawn with a small shaft exiting as the base foundation (figure 23). The upper link of each prawn will be connected to the shaft by one y axis motor ending towards a servo motor prawn grip mechanism (Orbray Co., n.d.).

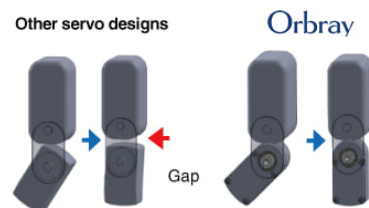
### Compact size / Low noise

Small step alignment structure



Optimized gear material, module, and safety factor  
Smallest servo in the industry  
Substantial noise reduction with original high-precision speed reducer

### Optimized design for robot articulation



Rounded arch of the small, thin servo makes sophisticated robot design possible

Figure 23: Design representation of the micro servo. (Orbray Co., n.d.)

On the base of the Quad-Prawns would be placed a 2megapixel camera projecting a live feed on the microcontroller for a more relaxed and efficient way of control and observation (ARDUCAM, 2024)(figure 24). Furthermore, with a built-in non-contact potentiometer, the motors would have high accuracy and collision detection for any object in their path. The compatibility of the camera is needed as-well, since it can be programmed through Raspberry Pi and Arduino. This would make electrical work safer as no contact with live wires will be made with the user, the prawns would also through circuitry be able to detect a live wire or current and voltage. All movement of prawns would be made via command from the microcontroller (joystick, dual pads) with the ability to

change speed and machine learning support for potential collision of prawn (figure 16).



*Figure 24: ArduCAM Mini Camera Module 2MP, (ARDUCAM, 2024)*

## 5.2 Construction/infrastructure

On another sector example, when working with public constructions or infrastructure is the ability to be prepared for different working environments and their complications. Designing a tool to detect obstruction within a wall could be detrimental when operating within an infrastructure while also minimizing damage while working. A perfect tool for this environment would be a drill tool with the ability to detect obstruction as to better navigate the user inside a complex environment in which the user by themselves cannot navigate.

For obstruction detection a DIY GPR (Ground Penetrating Radar) using a standard gain horn transmitter and receiver antennas, combined with a quad ridge horn (Karthikeyan. R, 2018)(figure 25).



Figure 25: Quad Ridge Horn Type, (Karthikeyan. R, 2018)

This is purely of concept as a normal priced GPR is worth around 15k euros, which would make the pricing way too big for the MCRT to have one tool costing more than half of the hardware needed for it. For the drill's output of the tool a simple dc motor(6v-12V) would be enough with accommodating drill ends, to be able to then connect the motor to the ESP8266, the L298N Driver will be needed with up to 3A handling, to be able to control the speed and direction via PWM (Microcontrollerslab, 2025)(figure 26).

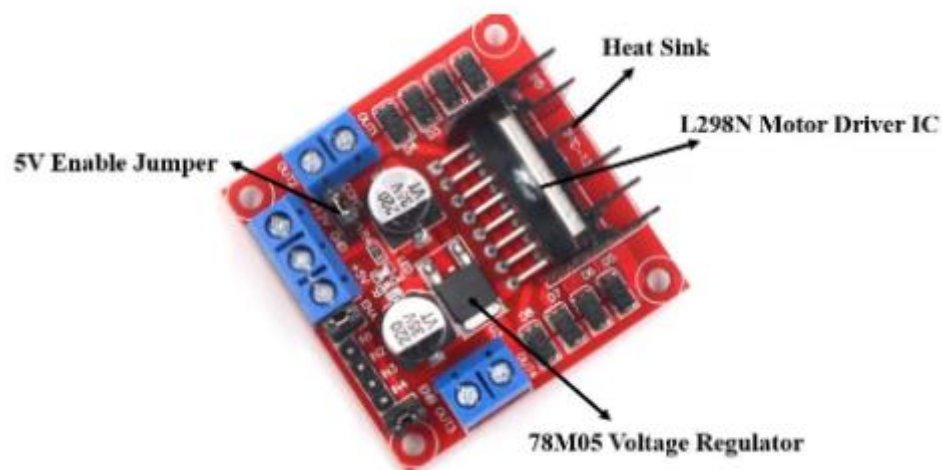
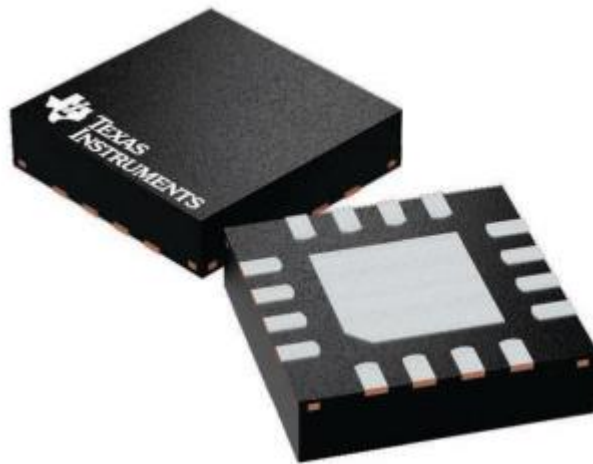


Figure 26: L298N Motor Driver Module, (Microcontrollerslab, 2025)

For a rundown of the DIY GPR sensor, the sensor has been proven possible to rebuilt via different sources and research papers (Karthikeyan. R, 2018). Using one transmitter dedicated to generating an RF signal between 1GHz to 20GHz, as well as a power amplifier to boost that signal, an RF receiver suitable for the signal range will be able to receive and then acquire the data of the reflected frequency signal via a data acquisition system (Texas Instruments, 2015)(figure 23) (Ineltek, 2025)(figure 24). An oscilloscope or software defined radio (GNU radio, SDR#) will be able to analyse the signal, calculate the distance as to being able to then visualize the data (Laurila, 2025).



*Figure 27: representation of the Texas Instrument RF transmitter, (Texas Instruments, 2015)*

The power amplifier will be connected to the output of the signal generator using coaxial cables which then the output of the power amplifier will connect to the quad ridge horn antenna (or QRH, figure 25).

The RF receiver module will then be connected to the QRH antenna in which the output of the receiver will be directly connected to the SDR to receive the data and translate it into visual, the program can be done through ESP8266 or python through the STM32F01 (figure 14) (STMicroelectronics, 2025). The Frequency will then be tested and when given the opportunity, the user will be able to change the frequency at will in different preexisting mode or manually designated button program activation.

## 6 CONCLUSION / MARKET POTENTIAL

Between all innovative industrial robots seen before and their comparable features to the MCRT, many of the main attributes of the CoRobots take away the freedom the MCRT is offering with the user. As this concept compound tool is envisioned to be, it is not suited for industrial automation but to generalize the usage of different tools needed for professional to use while working for industrial or development purposes without restricting the tool only for those concepts. The goal of this thesis is to prove how this concept is highly possible and could be of high potential in a market where engineers and other professional users, can be assisted without needing to invest in labs/workshops that require different machinery to operate on one thing at a time. Many other tools can be redesigned to match with the MCRT's dimensions and machine learning program to redefine them into long lasting tools. The vision is to commercialize this product in a wide range of markets as many people would benefit from the safety features as well as the efficiency, they can achieve making the workforce stronger.

## 7 REFERENCES

- ABB. (n.d.). *3HAC044075-001*. Retrieved from abb:  
<https://new.abb.com/products/3HAC044075-001/3hac044075-001>
- Adafruit. (2025). *2.8" TFT LCD with Touchscreen Breakout Board w/MicroSD Socket - ILI9341*. Retrieved from adafruit:  
<https://www.adafruit.com/product/1770>
- Adafruit. (2025). *Tactile Button switch*. Retrieved from adafruit:  
<https://www.adafruit.com/product/367>
- Adafruit. (n.d.). *Adafruit DRV2605L Haptic Motor Controller*. Retrieved from adafruit: <https://www.adafruit.com/product/2305>

- Allied Motion. (n.d.). *brushless DC motors*. Retrieved from alliedmotion: <https://www.alliedmotion.com/brushless-motors/brushless-dc-motors>
- ARDUCAM. (2024). *ArduCAM Mini Camera Module w/ 2MP Plus OV2640 for Arduino*. Retrieved from robotshop: <https://www.robotshop.com/products/arducam-mini-camera-module-w-2mp-plus-ov2640-arduino>
- ARDUCAM. (2024). *Arducam Shield Mini 2MP Plus*. Retrieved from arducam: <https://docs.arducam.com/Arduino-SPI-camera/Legacy-SPI-camera/Hardware/Arducam-Shield-Mini-2MP-Plus>
- COMAU. (n.d.). *Robotic Exoskeleton Suits with Improved Ergonomics*. Retrieved from comau: <https://www.comau.com/en/our-offer/products-and-solutions/wearable-robotics-exoskeletons>
- ELECROW. (n.d.). *ESP8266 IOT Board*. Retrieved from ELECROW: <https://www.elecrow.com/esp8266-iot-board-p-1591.html?r=YWxzb2Fk>
- High Temp Metals. (2015). *INCONEL 601 TECHNICAL DATA*. Retrieved from hightempmetals: <https://www.hightempmetals.com/techdata/hitemplnconel601data.php>
- HiTechChain. (2025). *1080P Sensor Raspberry Pi Infrared Wide Angle Fisheye 160 degree Camera Module*. Retrieved from hitechchain: <https://hitechchain.se/raspberry-pi/1080p-sensor-raspberry-pi-infrared-wide-angle-fisheye-160-degree-camera-module>
- HVH industrial. (n.d.). *What Is a Sprag Clutch and How It Works*. Retrieved from hvhindustrial: <https://hvhindustrial.com/blog/what-is-sprag-clutch>
- INC., P. (n.d.). *Brushless DC Motors*. Retrieved from phidgets: [https://www.phidgets.com/?prodid=1082#Tab\\_Specifications](https://www.phidgets.com/?prodid=1082#Tab_Specifications)
- Ineltek. (2025). *Holtek – Sub-1GHz Low-IF FSK RF Receiver BC2502A/B*. Retrieved from ineltek: <https://www.ineltek.com/en/rf-receiver-bc2502-holtek-sub-1ghz-fsk>
- JAI. (2025, March 11). *New 4K bilinear and monochrome line scan cameras!* Retrieved from jai: [https://news.jai.com/new-4k-bilinear-and-monochrome-line-scan-cameras?utm\\_referrer=https%3A%2F%2Fwww.jai.com%2F](https://news.jai.com/new-4k-bilinear-and-monochrome-line-scan-cameras?utm_referrer=https%3A%2F%2Fwww.jai.com%2F)
- John. (2024, September 11). *316 Stainless Steel: Definition, Composition, Properties, Processing, Applications, and More*. Retrieved from steelprogroup: <https://steelprogroup.com/stainless-steel/grades/grade-316>
- Karthikeyan. R, C. A. (2018). International Journal of Engineering and Advanced Technology (IJEAT). *Ground Penetrating Radar (GPR) Antenna Design.*, 9.

- Laurila, S. (2025). *IMPLEMENTING A MODERN SOFTWARE*. Tampere: Tampere University/ Faculty of Information Technology and Communication Sciences.
- Linengineering. (n.d.). *BL17 Series*. Retrieved from linengineering: <https://www.linengineering.com/products/brushless-motors/standard-bldc-motors/bl17-series>
- McMaster-CARR. (n.d.). *High pressure gas hose*. Retrieved from mcmaster: <https://www.mcmaster.com/products/high-pressure-gas-hose>
- Microcontrollerslab. (2025). *Interface L298N DC Motor Driver Module with ESP8266 NodeMCU*. Retrieved from microcrottollerslab: <https://microcontrollerslab.com/l298n-dc-motor-driver-module-esp8266-nodemcu>
- Moseman, M. (2025, January 10). *ABB Robots for Manufacturers: A DEVELOP Guide*. Retrieved from Develop LLC: <https://develop-llc.com/knowledge-base/manufacturers-guide-to-abb-robots>
- newegg. (n.d.). *3D Analog Joystick Module Potentiometer* . Retrieved from newegg: <https://www.newegg.com/p/2A6-0227-01GK0>
- Nordic Semiconductor. (n.d.). *nRF52832*. Retrieved from nordicemi: <https://www.nordicsemi.com/Products/nRF52832>
- NXP. (n.d.). *Arm Cortex-M4\_Kinetis K66 180 MHz 32-bit MCUs*. Retrieved from nxp: [https://www.nxp.com.cn/products/K66\\_180](https://www.nxp.com.cn/products/K66_180)
- NXP. (n.d.). *K66\_180*. Retrieved from nxp: [https://www.nxp.com/products/K66\\_180](https://www.nxp.com/products/K66_180)
- Orbray Co. (n.d.). *Micro Robot Servo*. Retrieved from orbray: <https://orbray.com/en/product/motor-unit/servo.html>
- SAMTEC. (n.d.). *USBR-B*. Retrieved from Samtec: <https://www.samtec.com/products/usbr-b>
- Seeed studio. (2025). *Grove - AHT20 I2C Industrial Grade Temperature&Humidity Sensor*. Retrieved from seeedstudio: <https://wiki.seeedstudio.com/Grove-AHT20-I2C-Industrial-Grade-Temperature&Humidity-Sensor>
- Sewport Support Team. (2025, July 24). *What is Polytetrafluoroethylene (PTFE) Fabric: Properties, How its Made and Where*. Retrieved from sewoprt: <https://sewport.com/fabrics-directory/ptfe-eptfe-polytetrafluoroethylene-fabric>
- Shlenkent Entreprises. (n.d.). *Torque Sensor*. Retrieved from schlenkent: <https://www.schlenkent.com/Torque-4503A.pdf>

STMicro Robotics. (2025). *STM32F401 Black Pill Board 84MHz 64K RAM*. Retrieved from robotics: <https://www.robotics.org.za/STM32F401CCU6-MOD>

STMicroelectronics. (2025). *STM32F4 series*. Retrieved from st: <https://www.st.com/en/microcontrollers-microprocessors/stm32f4-series.html>

Texas Instruments. (2015, march). *CC1150 Low Power Sub-1 GHz RF Transmitter*. Retrieved from ti: <https://www.ti.com/lit/ds/symlink/cc1150.pdf?ts=1753378756811>

T-MOTOR. (n.d.). *Cine77 3120 6kg Thrust Motor*. Retrieved from tmotor: <https://shop.tmotor.com/products/cine77-3120-6kg-thrust-motor-for-cinematic-drones?srsltid=AfmBOoqxIVvNuqc-KjjFRhJT7rJPn3uGN4LZpJ0uOcOrH6iuHFicsUVF>

Universal Robots. (n.d.). *Cobots*. Retrieved from Universal robots: <https://www.universal-robots.com/products>

UNIVERSAL ROBOTS. (n.d.). *UR16e*. Retrieved from universal-robots: <https://www.universal-robots.com/products/ur16e>

wh\_hsn. (2015). *Introducing PlatformIO for ESP8266*. Retrieved from Autodesk Instructables: <https://www.instructables.com/Introducing-PlatformIO-for-ESP8266>