

MOTION TRACKING ROBOTIC ARM (MTRA)

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ABSTRACT

Robotic arms have been widely used in the past three decades to fill demands created by the market. One of those demands is creating a safe environment for chemists or lab-technicians when dealing with dangerous substances. The objective of this project was to develop an intuitive, relatively easy to use motion tracking Robotic Arms, (MTRA).

The concept is based on a motion tracking system for a robotic arm which allows the user to use their own extremities to control the robotic arms at a safe distance. The aimed user and designated environment in this project are to be between the chemistry lab technician and the laboratory fume hood. A device which uses two cameras and three tracking infrared sensors will track the position and the orientation of a user's hand and forearm. The data collected will be used as orientation for the robotic arm that will, in turn, mirror the user's movement. The robotic arms will have 6-axis of motion to provide more flexibility and freedom to the users when executing different tasks and maneuvers.

Another aim of the project is to lower the manufacturing and operation cost of such technology. That would be achieved by adopting technologies such as 3D printing to acquire parts for the robotic arm build and the use of newer microcontrollers which are able to perform the same tasks but at a lower cost. The result of the aforementioned would cause wide market adaptability and solving one of the main problems face such a project which is cost-related issues.

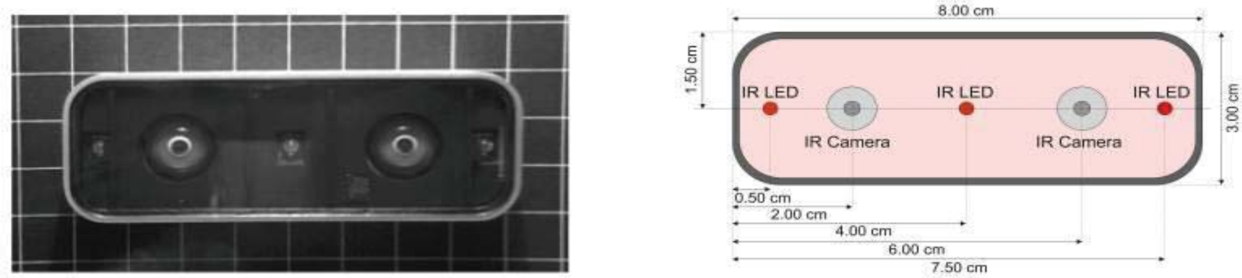
Keywords: robotic arm, 3D printing, motion tracking Robotic Arms (MTRA), 6 axis motion.

INTRODUCTION

For the past centuries, robotic arms have been an elusive dream for scores of inventors, engineers and industrialists alike [1]. Da Vinci was one of the first inventors (1495) to design a sophisticated robotic arm with four degrees of motion and an analog onboard controller to supply power [2]. Fast forward to 1954, a patent was filled by the inventor George Devol for a mechanical arm which was later named Unimate. The prototype was first used in 1961 by General Motors on an assembly line at their die-casting plant in Trenton, New Jersey [3]. That marked the first time a robotic arm was used on an industrial scale to perform jobs that proved hazardous for factory workers.

As previously mentioned, not all environments are fit for human health. However, as our scientific grasp expands, people have become more knowledgeable in many disciplines that tread into the hazardous environment unfit for human contacts. Professionals dedicating themselves to such disciplines would expose their health to unsafe environments to achieve the objective of their discipline. This causes the need to create a mode of interaction that would allow the user the ability to remotely physically manipulate objects within a high-risk environment without putting the user's health on the line. Such a mode of interaction will allow professionals to explore and work in an unhealthy environment and expand our human scientific capabilities. Therefore, this project introduces MRTA as a solution. MRTA will help the user avoid any hazardous chemicals and stay within safer distance.

The aim of this project was to build a robotic arm that is able to mimic the natural capability of human arms through the use of motion tracking. In other words, this project will use infrared sensors to detect human hand activities and movements. The infrared sensors result in a detailed reading of the motion produced by the human hand, and along with coding, the motion is transferred to the robotic arm. In order to achieve this goal, a motion reader was obtained from Leap Motion (Figure 1), and the values obtained are then used to map the motion of the glove in a virtual space [4]. The collected sensory data was passed to a microcontroller which, in turn, allows the robotic arm to mimic the motion of the hand.



(a) **(b)**

Figure 1. (a) top view of “leap motion” device. **(b)** a detailed diagram showing “leap motion” components and dimensions.

METHODS

Motion tracking

For motion sensing, a device called Leap Motion**,** manufactured by LEAP MOTION, INC is used. This device is equipped with cameras and infrared sensors which are able to map a limited space surrounding it and tracks the movement of hands to one-hundredth of a millimeter with a 150-degree field of view. It can recognize a human hand and forearm, creating in real time a digital version of the hand. This enables the user to manipulate digital objects with hand motions. The creators of leap motion have created an application suite that includes available software that can be used in tandem with industry known hardware such as Arduino or raspberry-Pi.

Robotic Arm Assembly

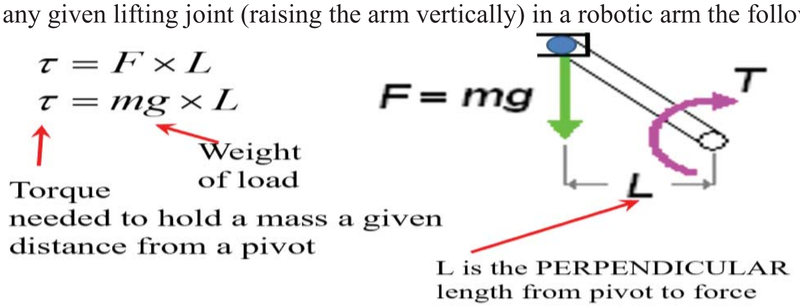
This part of the project is known to consume a lot of time. As the assembly procedure of the arm is hectic, the process is well worth it. The MTRA as mentioned before will consist of an arm, index finger, thumb, paw, and claw. Since the motion sensors in use help imitate the human's hand motion, the robot needs a human user. This results in the use of humans to operate this project. In other words, knowing that there’s a fear regarding robots taking out a lot of regular jobs, here it is proven otherwise. Some of the parts used in this arm were 3D printed while other parts were made out of aluminum. The reason aluminum was used because it is cheap, durable, and light in weight. As a result, the arm wouldn't be as heavy. Examples to improve the materials used to build the robot instead of aluminum and PLA (Polylactic Acid) Biodegradable Filament will be Carbon Fiber.

Coding

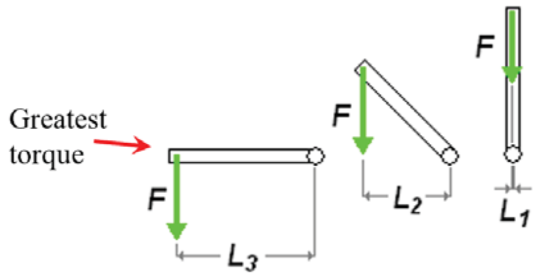
To program the arduino microcontroller, Arduino IDE (integrated Development Environment) is used. Arduino IDE is the main text editing program used for Arduino programming. This is where the code is typed before it is uploaded to the board for programming. Arduino IDE is based on C++ language with an addition list of instructions and functions. These instructions can be added on using libraries depending on the specific project. C++ is an easy readable programming language.

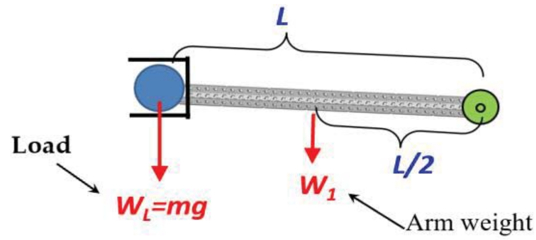
Mathematical Formulation

The most important concept to be understood in this section is the torque obtained and produced. Since it is a robotic arm, most of the motion considered will be rotational. there are two types of masses to be considered. Not only the mass of an arm or parts, but also the mass of the actuators and the mass of the links within the arm. To determine the torque required at any given lifting joint (raising the arm vertically) in a robotic arm the following formula is used.



The Length is in cm, the Mass and Actuator’s mass is represented in Kg, and the Torque is represented in Kg.cm. The values for L, M, and A will be measured with respect to the units.To estimate the torque required at each joint, the worst case scenario must be accounted for.





$$\tau = (mg \times L) + (W_1 \times L/2)$$
$$= L(mg + W_1/2)$$

As the robotic arm rotates clockwise, L, the perpendicular distance decreases from L3 to L1 (L1=0). Therefore the greatest torque is at L3 (F does not change) and torque is zero at L1. Motors are subjected to the highest torque when the arm is stretched out horizontally. Also the torque imposed by the arm itself must be accounted for. Once the values measured are obtained and inserted in the table below, the calculations are automatically made and result in a value for T.

The fingers regardless would be related to Torque and Stress as well. Since the use of grip is crucial at the hand part of the robot, stress is a very important factor. Stress analysis was introduced in this part of the arm, resembling the possibility and variability of how heavy an object may be.

RESULTS

In order to bypass the evolutionary limitation of human physique, there has been an increasing need for a human to be able to remotely act in a hazardous environment to save the lives of the people involved. Bolstered by the case of *two drops of death*, as experienced by Karen Wetterhahn who suffered from neurological symptoms and died within a year. The chemist studied toxic metal exposure and unknowingly exposed herself to organic mercury through her lab gloves. Many lives can be saved while humanity put forth itself into many ill-disposed environments for various endeavors. The MTRA helps prevent such incident by having the users do their jobs using the motion tracking instead of actually performing experiments, as a result, the robotic arm will implement it in actual stages of work. Particularly, if a chemist wants to add two chemicals together, for instance, they can hold empty beakers instead of filled ones while the robot holds the filled ones and mirrors the user's movement.

Environmental Impact

The main motivation for creating the MTRA is its unequivocal environmental impact. As humans are required to put ourselves in a health-damaging environment to achieve certain feat, scientific and other efforts push humans to operate in environments that exceed the human health limitations and quality of life. MTRA also allow human operation in the environment that need the minimum interference such as clean rooms. It doesn't only help improve the environment, but also save lives.

Economic Impact

With regards to the economic impact, MTRA allows business to incorporate the human factor into the business operation, thus bringing the consumer back to the production process. This prevents the alienation of human factor in the economic flow of wealth. The multifaceted human cognitive function is indispensable in complex pattern recognition, self-learning, self-correction, and the psychological wellness of the consumer. MTRA allows all this to be possible while reducing the risk factor of the certain environment but still utilizing the intricate flexibility of human arms and hands. Since MTRA utilize motion detectors and mimic human motion, it lowers the user's learning curve and creates a seamless transition from the former way of operation. This also allows the use of existing tools that are to be operated by human hands through remote manipulation. Lastly, the widen possibility of human capability in a hazardous environment can also be used to tackle epidemics, minimizing casualties, increasing the human resource, which can be allocated to use for the utmost benefit.

Social Impact

The Social impact of MTRA can be seen through the culmination of the environmental and economic impacts. As Karen Wetterhahn, many professionals worked tirelessly while endangering their quality of life. To be able to safely and remotely handle toxic materials will lead to new discoveries that will save countless lives. As mentioned above, the livelihood of the community shall be preserved through the inclusion of the human factor into the economic flow. This will create new employment opportunities and dispelled the fear of being replaced by automation in the near future. The MTRA can work in any environment, adding to its flexibility. As robots generally help eliminate dangerous jobs on humans, the MTRA satisfies this task, especially with chemists.

Tables 1 and 2 present the descriptive statistics and ANOVA results. The following results focus on the main effects of the different Lokomat settings which are presented as the group result (mean, SD) of the relative change due to one factor while the other two factors were collapsed.

CONCLUSION

The MTRA approaches chemistry in an innovative smartness. The use of robots is widely known in today's world; however, most if not all, occupy professions from humans. This robotic arm ensures the complete opposite. Consumers will gain experience, knowledge, and jobs, he or she will be trained and well equipped to use the MTRA.

Our approach combines the strengths of discriminative classification and generative pose optimization. As presented for the first time, a hand tracking object based on a motion sensor such as LEAP to be used with a chemistry robotic arm to impersonate human motion. We used 3D PLA Filament to print parts that weren't in production. Such action resulted in nimbler and more appropriate fit for the robotic arm. The tracking was performed by the LEAP sensor where two infrared sensors captured every motion with every detail, then conveyed this motion using a computer power supply to the robotic arm. Using the LEAP was the best solution to prevent any lagging and responsive issues. In fact, resulted in more accurate reading and robust outcomes. Additionally, we believe publicizing this paper to help future research will be significantly supportive.

DISCLOSURES

Financial Disclosures: The authors have no financial disclosures. **Conflicts of Interest:** The authors have no conflict of interest to declare.

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