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THE USE OF ASSISTIVE ROBOTICS IN PROMOTING MOVEMENT AT THE ELBOW JOINT

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Introduction

The use of assistive robotics in healthcare is a relatively new concept which has been growing over the 21st century. The clinical use of an assistive robot in a rehabilitative context is to support the movement of a person with a degree of motor impairment (Reinkensmeyer, 2021). Evidence from Malik *et al.* (2016) and Lo *et al.* (2017) suggests the use of assistive robotics in rehabilitation and physiotherapy improves outcomes for a wide variety of patients, such as post stroke patients (Figure 1) or patients with neurological disorders, such as cerebral palsy.

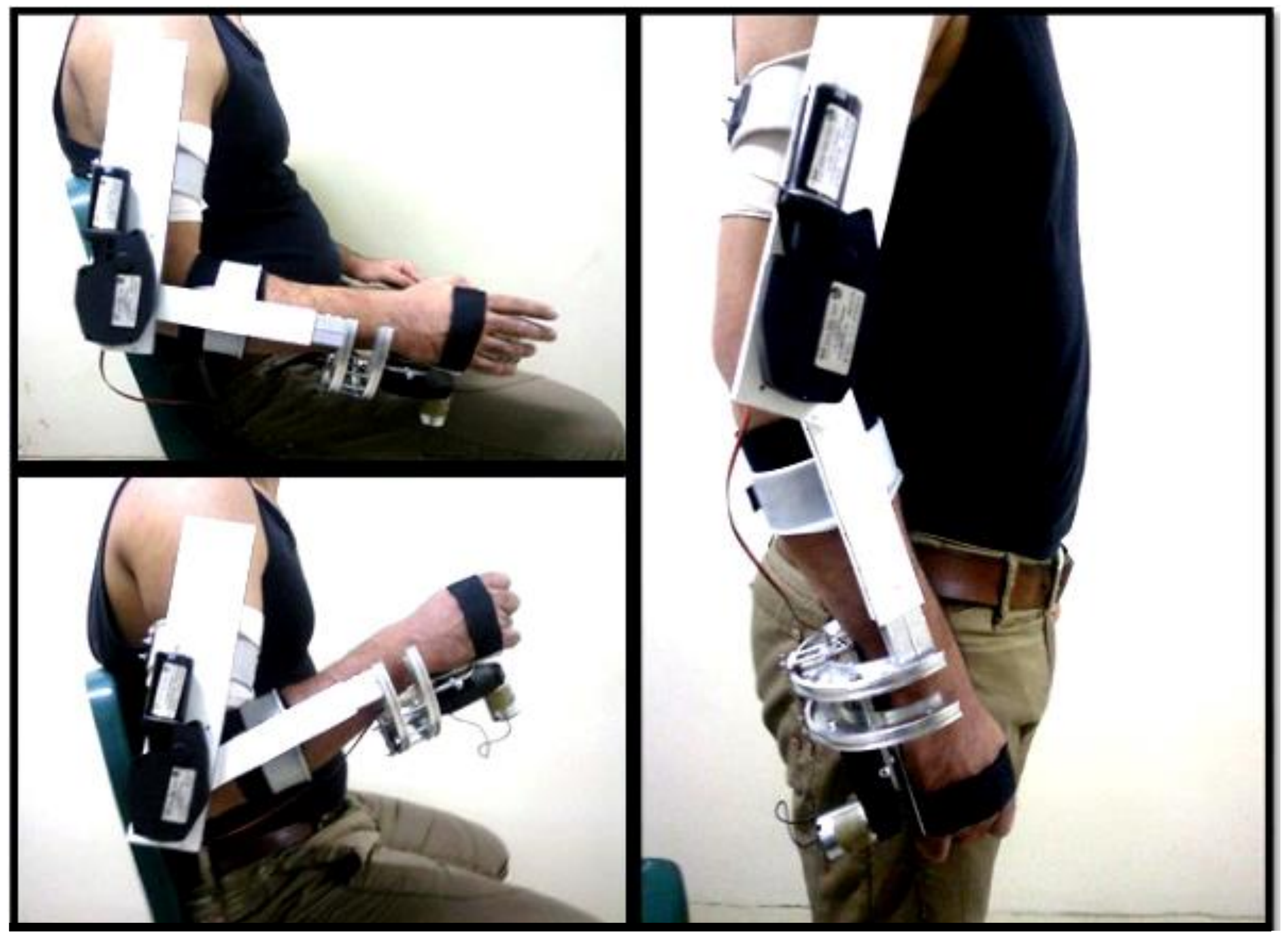

Figure 1: an example of an assistive device used to facilitate flexion and extension of the elbow joint (Image taken from Mohammedi, Zohoor and Khadem, 2016).

Methodology and Development of Design

Fusion 360® was used to develop a design that would be lightweight and functional in assisting the movement of a joint. The design featured an active actuator connected to an external power source such as a battery. A servo motor was decided to act as the actuator since the angle of rotation can be limited, making it safer in a patient context. A force sensitive resistor was selected as the sensory input of the device. This made for simple mapping to be used in coding to align a given force applied to the sensor to be proportional to a rotation from the actuator by a corresponding angle. This provides more control to the patient when moving the joint.

Initial prototypes were enclosed and bulky, which would have several limitations in practice. Fitting the device to the arm of the patient may be difficult, especially if the patient would prefer to wear it under clothing. From a practical perspective, 3D printing of the bulky structure (Figure 2) would also be excessively time consuming, which therefore limits production and number of patients with access to the joint.

Several modifications were made to the design in order for it to be more practical and comfortable for patients. A lighter, open design (Figure 3) was favoured because it can be fitted more securely to the arm of the patient. This ultimately makes the joint more convenient for the patient as it prevents sliding or rubbing against the skin. The newer design was also significantly faster to print, making it more readily available to patients when needed.

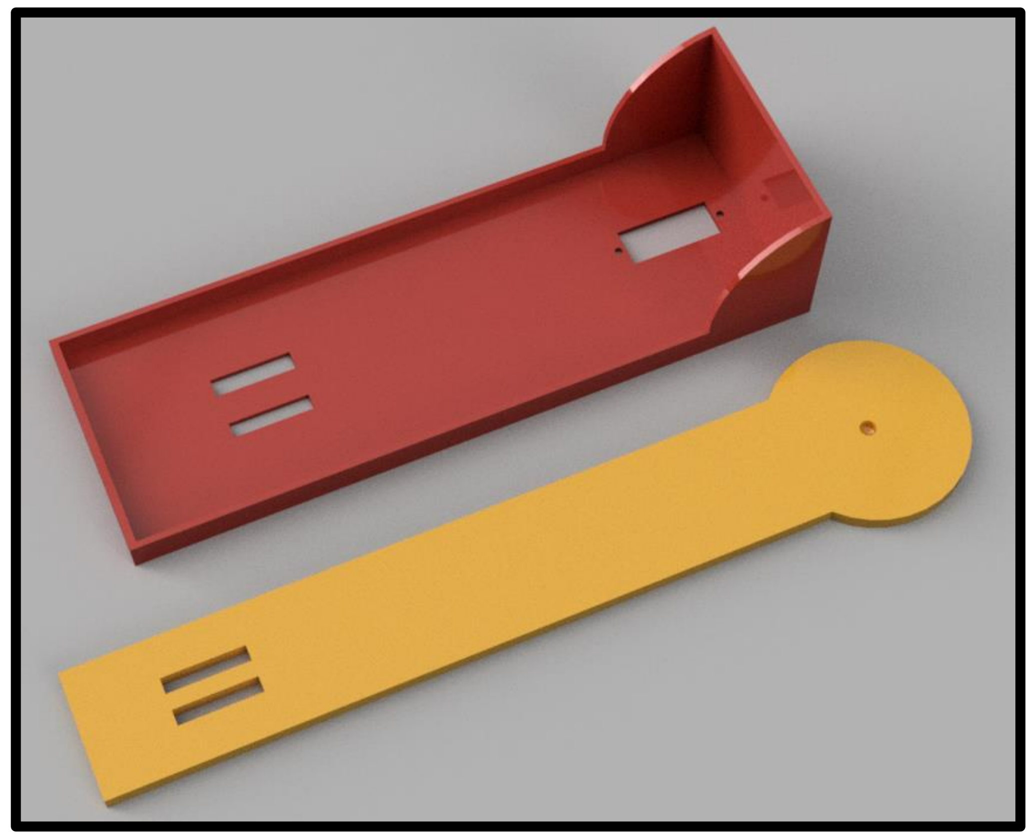

Figure 2: the separate components of the final design.

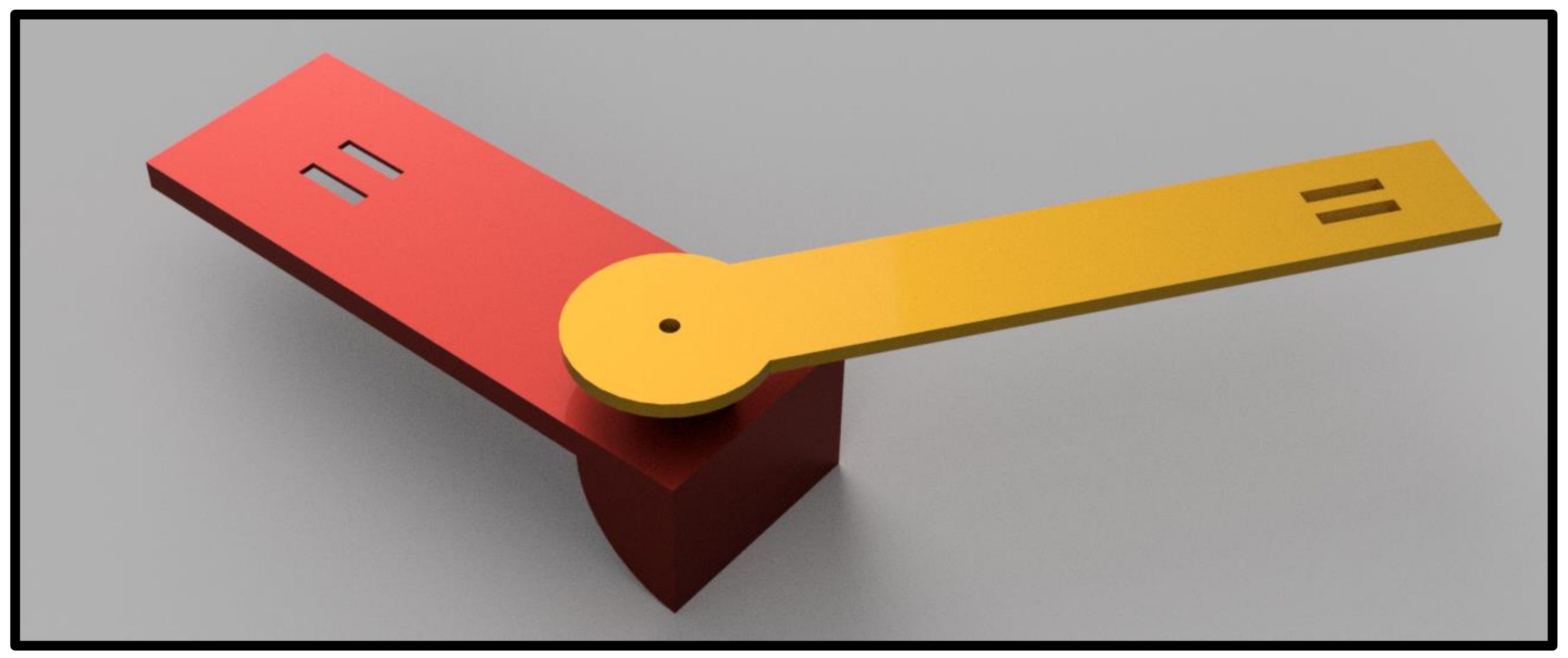

Figure 3: the assembled components of the final design.

Results

The final product, when combined with the pre-made circuit and motor, was able to rotate as intended. When scaled to the size of a human arm, and with a sufficient motor, it appears that the product could produce movement to allow for flexion and extension at the elbow joint. The speed at which the joint moved appeared slow enough to be comfortable for the patient, but also fast enough not to make the movement tedious or inefficient. The coding in the sensor and motor allowed a force produced by the fingers of the patient against the resistor to generate rotation of the motor. When using the device, it became apparent that in order for the joint to flex fully, a large amount of force is required, which presents a number of limitations.

Conclusion

The initial aim of this project was to use software such as Fusion 360® and Arduino to form a functional device which can assist in flexion and extension of the elbow joint. The device uses 2 components which are connected via a servo motor, Arduino circuit board and force sensitive resistor. In conclusion, the end product fills the role of an assistive robot, which was defined during the introduction. One particular benefit of this product is that it is simple to make and use. This means the product can be made readily available for a number of patients and only a minor amount of healthcare professional time will be needed in order to teach them how to use the device. The major limitation of this device is that patients will need to apply a large amount of force to the resistor in order to completely flex the joint. This means patients with certain neuropathies or myopathies would not be able to generate enough force to flex their elbow. Ultimately, this limits the number of patients who can benefit from our device and therefore in future projects, coding may need to be altered so a more manageable force is required to fully flex the joint.

References

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