

A MINI-REVIEW OF KINETIC STUDY ON SHOULDER JOINT USING KUKA LIGHTWEIGHT ROBOT

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DOI: 10.47750/pnr.2022.13.S06.374

Abstract

A Traditional physiotherapy sessions are long and demanding, requiring a lot of effort and time from both the physiotherapist and the patient. The KUKA LWR's high work capacity and consistent precision of end-effector location and movement were utilized to solve these issues. The KUKA LWR is a seven-degrees-of-freedom robotic manipulator designed for applications in which the robot must be near the human operator. During shoulder flexion exercises, which are commonly employed in traditional physiotherapy sessions, the robotic system pretends to analyze upper-limb behaviour, specifically the shoulder complex.

Keywords: Physiotherapy, KUKA Lightweight Robot, Shoulder Joint

INTRODUCTION

The shoulder complex is the region that connects the proximal part of the arm, the thoracic trunk and the neck. The shoulder is a complicated joint with a large range of motion and a variety of functional needs. To correctly identify and diagnose shoulder pathology, one must have a thorough awareness of the complex network of bony, ligamentous, muscular, and neurovascular anatomy. There are several articulations, anatomical characteristics, and anatomic linkages that influence shoulder function and, as a result, dysfunction and injury. (1) The structure and function of the sternoclavicular and acromioclavicular joints are described, as well as scapular motion. (2) The shoulders are frequently assessed by palpation and some basic exercises to test the strength and range of motion of diseased limbs, in addition to observing the patient's posture and movement coordination. Controlling a vector quantity such as position or force is insufficient when considering the physical limits imposed by dynamic interaction; control of the manipulator impedance is also required. (3) The steady and continuous motion that happens simultaneously at the scapulohumeral and scapulothoracic articulations during arm elevation is referred to as scapulohumeral

rhythm. (4) The shoulder complex is made up of four different joints. Between the acromion and the clavicle is the acromioclavicular joint. A coordinated motion of the shoulder complex, which includes the glenohumeral (GH), scapulothoracic, sternoclavicular, and acromioclavicular joints, results in the global range of motion of the arm. (4) The anteroposterior and longitudinal movements, as well as some axial rotation, are all controlled by this joint. The AC joint's major function is to preserve biomechanical connection and integrity between the clavicle and the scapula, as well as to allow the latter to achieve an additional range of rotation during the last phase of upper limb elevation. (5) The glenohumeral joint, a spherical joint that is located between the humerus head and the glenoid cavity, is the glenohumeral joint, a spherical joint. Flexion, extension, abduction, adduction, medial rotation, lateral rotation, and circumduction are all possible with this multiaxial joint. (2) Two other joints are involved in shoulder movement, in addition to the acromioclavicular and glenohumeral joints. The sternoclavicular joint connects the collarbone's proximal portion to the stern. It's also a synovial joint that allows for anteroposterior and longitudinal collarbone movements, as well as minor rotation. The fundamental purpose of the SC joint is to keep the upper limb in osseous contact with the axial skeleton, which helps with movement and stability. (6) The scapulothoracic joint is the shoulder's joint. Unlike other physiological joints, this one is not made up of fibrous, cartilaginous,

or synovial tissue. Instead, numerous muscles and bursae engage with the scapula and ribs to generate the scapulothoracic joint, allowing it to slide down the thoracic trunk.

(7) The only attachments between the scapula and the thoracic trunk are those with the Acromioclavicular and Sternoclavicular joints, which constitute a closed chain mechanism that is responsible for joint stability. (7) The scapulothoracic joint is extremely flexible and allows for a wide range of motion. The scapula slides along the thoracic trunk in a specific direction during normal shoulder movement, depending on the pressures exerted by the muscle attachments, resulting in protraction (abduction), retraction (adduction), elevation, depression, and rotation. (5)

Due to the limitations of one-on-one manually aided physiotherapy, such as its intensity and time commitment, as well as budget constraints, robotic devices that can partially substitute human work have been introduced. The goal was to automate

sessions and make use of robots superior working capabilities, ensuring task perfection throughout the rehabilitation sessions. In this approach, rehabilitation robots can improve clinician productivity and efficacy by partially replacing the physical performance of rehabilitation exercises by physiotherapists, allowing them to treat multiple patients at once. (8) The first step in identifying the underlying neuromotor strategies present in the upper limb is to understand the mechanical features of the human limb and how they vary throughout the execution of functional tasks such as gripping an object. The human upper limb's adaptability and robust mechanical interface in an unpredictable environment allow it to dynamically alter its characteristics to unexpected destabilising stresses while maintaining a stable posture. The upper limb's musculoskeletal system is compliant when it comes into contact with a range of things due to its dynamic but stable mobility.

When it comes to human-robot interactions, safety is crucial (HRI). Robots are capable of making forceful movements that can endanger humans in their vicinity. To avoid mishaps, it's crucial to identify potential sources of injury, establish which of the people in the robot's vicinity is most at risk, and assess the kind of injuries the robot could cause this person. (9) Robotic-assisted techniques have the potential to improve the rehabilitation process. They can help with not just the therapeutic outcome, but also clinical evaluation and patient motivation. (10) Even with these restrictions, studies show that the regulations in place do not protect human co-workers because the bulk of incidents happen during maintenance, repair, setup, and testing when the operator is in the risk zone. (11) The workspaces of both robotic and human arms were compared by determining if a certain subregion of the workspace could be reached by both. The Reachability Index determines how accessible a subregion is, or what proportion of the precise locations and orientations evaluated can be reached by the human/robotic arm for this subregion. The comparison was then carried out recursively by determining which of the specific attainable poses of the human arm in each subregion related to reachable poses in the KUKA LWR workspace. In this study, the ergonomic configuration, which is comparable to the configuration used in this paper, produced better outcomes.

The physiotherapist chooses the best rehabilitation exercise to conduct based on the patient's individual needs. To correctly do this exercise without the influence of the physiotherapist's hand, the robot must rely on valuable data regarding the movement.

The evolution of the tool position (or simply the trajectory) and the contact forces between the physiotherapist, the robot, and the patient arm that make this movement possible are the most significant movement aspects. The physiotherapist is in contact with the KUKA LWR and the patient's arm as part of the system. The robot is set to compensate for gravity and allows the physiotherapist to choose which movement to do. The position and orientation of both the shoulder and wrist reference frames must be determined. Two acquisitions were made with the KUKA LWR and the Human-Robot Coupling Tool for one rehabilitation session. The first establishes the shoulder's reference frame about the KUKA LWR base. The first step in identifying the underlying neuromotor strategies present in the upper limb is to understand the mechanical features of the human limb and how they vary throughout the execution of functional tasks such as gripping an object. The human upper limb's adaptability and robust mechanical interface in an unpredictable environment allow it to dynamically alter its characteristics to unexpected destabilising stresses while maintaining a stable posture. The upper limb's musculoskeletal system is compliant when it comes into contact with a range of things due to its dynamic but stable mobility. (12)

KUKA LWR

KUKA LWR is part of a revolutionary generation of robots whose primary application is to assist and collaborate with humans in a variety of jobs at home, in the office, or public spaces such as hospitals and rehabilitation centres. The KUKA LWR is a seven-degree-of-freedom (DoF) robotic with the ability to work in congested and unstructured environments with limited

knowledge about the surroundings. (13) The elevation of the KUKA LWR and the posterior base positioning relative to the patient, on the other hand, was judged a reasonable approximation to the Ergonomic Configuration proposed, resulting in a better overlap of workspaces. (9) The term "lightweight robot" refers to a robot whose weight has been lowered to the absolute minimum practicable, as opposed to prior generations of robots whose great position accuracy necessitates high stiffness at the expense of a high robot mass relative to its payload. (14) The system's powerful motors and lightweight structure enable effective vibration dampening, which is critical for trajectory following, providing it with the accuracy and repeatability required for KUKA LWR rehabilitation exercises. (14-25) Because this is an environment where the robot is in constant contact with the patient and, in some stages, with the

physiotherapist, the robot's positioning during a physiotherapy session is critical. This arrangement must ensure that there is minimal interference between the workspaces of the patients' arm and the robotic arm, reducing the risk of collisions and both reaching their joint space limits. (26-37)

CONCLUSION

The goal of this project was to create a robotic system that could correctly conduct traditional physiotherapy exercises like shoulder flexion while co-manipulating the KUKA LWR, much like a physiotherapist would. In this way, the strengths of both humans (decision-making capability) and robots (accuracy, labour capacity, and repeatability) could be used to improve arm musculoskeletal rehabilitation. The robotic system and earlier communications configuration allowed the creation of tactics to regulate KUKA LWR behaviour during a physiotherapy session. The devised system was capable of accurately replicating the physiotherapist's movement at various speeds and with the required number of repetitions. The non- pathological shoulder of the seven people who took part in the testing revealed that the physiotherapist's action while co- manipulating KUKA LWR with the impedance tunnel was extremelcomparable to KUKA LWR's activity during the shoulder flexion movement.

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