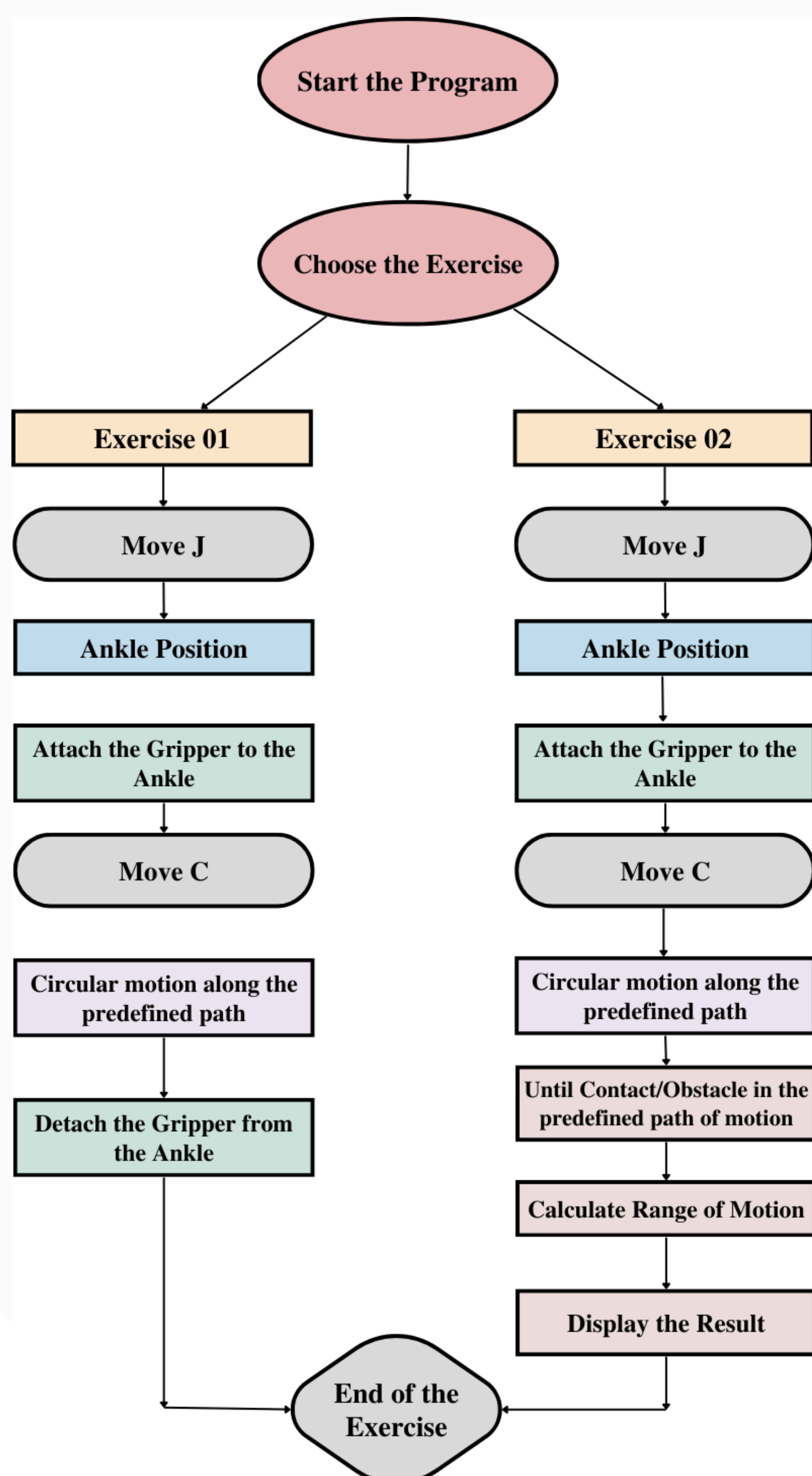


I. Introduction

This study explores the development of a robot-assisted knee rehabilitation system using the Universal Robot UR3. The system replicates two critical physiotherapy tasks knee flexion/extension and range of motion (ROM) measurement. A mannequin knee joint serves as the simulated patient, and the system utilizes precise robot programming with the URSim platform. The system demonstrates high accuracy and repeatability, offering potential applications in clinical rehabilitation settings. This paper details the design, implementation, and evaluation of the system.

Block Diagram



III. Methods and Result

Rehabilitation Exercises

- Replicates physiotherapist-guided movements using robotic control.
- Focuses on knee rehabilitation exercises post-surgery.

Knee Flexion/Extension

- Enables controlled knee joint movement with smooth flexion and extension, defined by a via point (curvature) and an endpoint (final position).
- Ensures natural transitions to simulate realistic knee mechanics.



Range of Motion (ROM)

1) Resistance Detection

- Uses Force and Until Contact commands to detect resistance and halt.
- Recorded Initial and final positions to calculate ROM.



2. Angle Calculation

$Result_{initial} = Pose_Trans(Pose_Inv(Patient), Initial_Pos)$
 $Result_{final} = Pose_Trans(Pose_Inv(Patient), Final_Pos)$

-Extract coordinates from $Result_{initial}$ & $Result_{final}$
-Compute Angle

$$\begin{aligned} angle1 &= atan2(y_1, x_1) \\ angle2 &= atan2(y_2, x_2) \\ rom_angle &= angle2 - angle1 \\ rom_degree &= \left(\frac{rom_angle \times 180}{\pi} \right) \end{aligned}$$

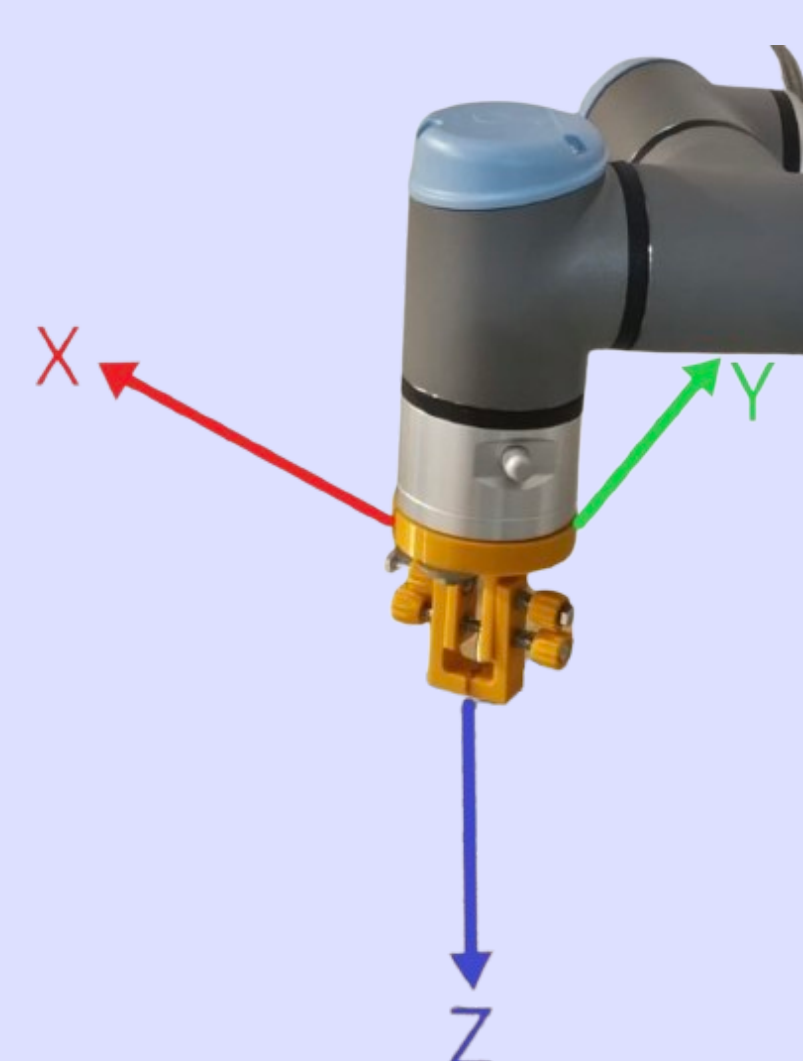
II. Materials

NAME	X(mm)	Y(mm)	Z(mm)	RX(°)	RY(°)	RZ(°)
TOOL	0.0	0.0	74.35	0.0	0.0	45
FRAME	111.68	-322.94	45.76	125.38	-129.40	-8.02

Robot Specification

Tool: 3D printed gripper is employed to attach it to the ankle of the knee mannequin hence assisting the robot to hold the knee mannequin and perform motion.

Patient Frame: Positioned from the initial point of knee joint



IV. Conclusion

The robotic-assisted knee rehabilitation system automated key physiotherapy tasks, including knee flexion/extension and ROM measurements showcasing precision, repeatability and safety with the UR3 robot. While tested on a mannequin, it proved feasible for clinical use. Future advancements, such as integrating real-time feedback, adaptive algorithms, and testing on patients, can enhance its adaptability and revolutionize post-surgical knee rehabilitation.

Reference

[1] ABDI, A. , KELAIAIA, R. , BRAHMIA, A. and LATRECHE, A. 2024. State of the Art on Lower Limb Rehabilitation Robots. Algerian Journal of Signals and Systems . 9, 2 (Jun. 2024), 68-77. DOI: <https://doi.org/10.51485/ajss.v9i2.213>.