

## 1. Name of the Project

Robotic Knee Rehabilitation System: An application that helps patients to recover from injuries.

## 2. Name of the each of the team members

- Mahdi Islam
- Musarrat Tabassum

## 3. Robot that will be used

**Universal Robot (UR3):** The UR3 is a compact, collaborative robotic arm which is designed for tasks requiring precision and is suitable for repetitive motion, controlled tasks make it ideal for the knee rehabilitation project.

## 4. A Brief Explanation of the Real Procedure Performed in the Surgery Room

This is not a typical surgery; rehabilitation procedures are required after knee surgery; for example; knee replacement or ACL surgery that often involve carefully controlled exercises to restore range of motion and rebuild strength.

Knee rehabilitation procedure in a clinical setting:

### Initial Assessment

A physiotherapist assesses the patient's range of motion and observes how far the knee can flex and extend as well as the strength of the surrounding muscles.

### Flexion/Extension Exercises

The patient performs exercises to bend and straighten the knee. The physiotherapist helps to perform this exercise within a safe range of motion to avoid any injury to the recovering tissues.

Initially, these movements are guided by a therapist before progressing to the stage when the patient can do this alone, gaining strength.

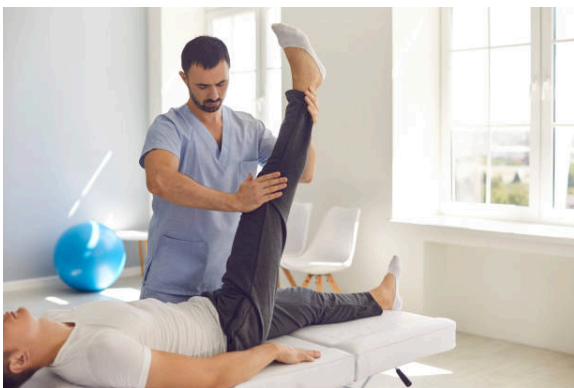


Figure 01[1]

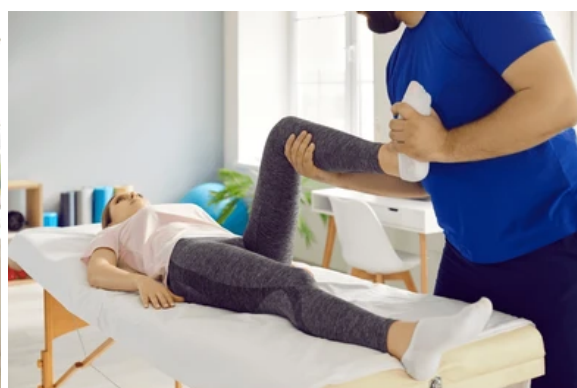


Figure 02[2]

### Range of Motion Testing

This step is the evaluation done by the therapist to see how far the knee can move safely without pain or resistance. The therapist measures the maximum flexion and extension angles.



Figure 03[3]

### Resistance Simulation Exercise

Once the range of motion is restored, resistance exercises are introduced. These exercises involve the application of force against the knee's movement helping rebuild muscle strength around the knee joint.



Figure 04[4]

### Continuous Monitoring

Throughout rehabilitation, the patient's progress is measured and monitored ensuring that they are gradually regaining mobility and strength.

## **4. Explanation of the part that will be replicated & Objectives**

The project will replicate the flexion/extension exercises, range of motion testing, and resistance simulation exercises that are typically done in a physiotherapy session after knee surgery. This will be done using the UR3 robot and a mannequin bone model to simulate knee movements.

## Objectives

### Flexion/Extension

- Simulating controlled knee flexion and extension exercises using the UR3 robot.
- Ensuring precise and safe movement within a pre-calibrated range of motion.

### Range of Motion Testing

- Measuring the maximum range (flexion and extension angles) of the mannequin knee joint.
- Collecting data on how far the knee joint can move in a controlled setting.

### Resistance Simulation Exercise

- Applying controlled resistance against the knee's movement to simulate muscle strengthening exercises.
- Measuring how much force is required to overcome different levels of resistance.

## 5. Explanation of the setup that will be used

The setup will include the following components:

- **UR3 Robotic Arm:** The UR3 will be programmed to perform controlled flexion/extension movements, test the range of motion, and apply resistance during the resistance simulation exercises.
- **Mannequin (Bone Model):** A mannequin's bone model of the knee joint will be placed in a fixed position on the workspace of the robot.
- **Mounting Frame for the Mannequin:** The bone model will be fixed in place on a stable platform to ensure that the UR3 can perform accurate, repeatable movements without displacement.
- **Force Calibration Tools:** If a force/torque sensor is available, it will be used to measure the force applied during resistance simulation. If unavailable, pre-defined force parameters will be used to simulate resistance.

## 6. Tool and Plan on Fixing it to the Robot

**a) Tool:** The UR3 will be equipped with a customized end-effector that will attach to the knee joint to perform flexion/extension and apply resistance during movement.

**b) Fixing to the robot:** The tool will be mounted on the UR3's flange or end of the robotic arm. The attachment will be designed to securely hold the knee and allow the robot to safely manipulate the joint.

## 7. Mock-Up that will be used

Mannequin Bones: The mock-up will be a mannequin bone model representing the knee

joint, including the femur, tibia, and patella. The bones will be fixed on a platform to simulate a realistic knee joint, and the UR3 robot will interact with the bones to perform the rehabilitation exercises.

## **8. 10-Session Plan for the Knee Rehabilitation Project Using UR3**

Session 1: Familiarize with the UR3, set up workspace.

Session 2: Attach tool, basic movement tests.

Session 3: Set up mannequin and calibrate for flexion/extension.

Session 4: Implement flexion/extension movements.

Session 5: Calibrate for range of motion testing.

Session 6: Implement range of motion testing.

Session 7: Set up resistance simulation.

Session 8: Implement and refine resistance simulation.

Session 9: Integrate all operations into one routine.

Session 10: Final testing, data collection, and documentation.

## **References:**

1. <https://www.istockphoto.com/es/search/2/image-film?phrase=knee+flexion>
2. <https://www.shutterstock.com/search/knee-flexion>
3. <https://www.athleticpt.com/what-is-range-of-motion/>
4. <https://www.physiotutors.com/wiki/knee-resisted-isometric-testing/>