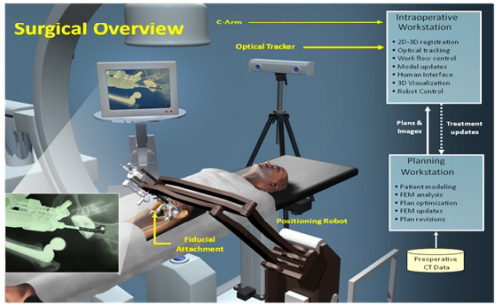
Mini Check-Point Presentation

Position Control of BIGSS Lab Snake for Revision Total Hip Arthroplasty (THA) Surgery

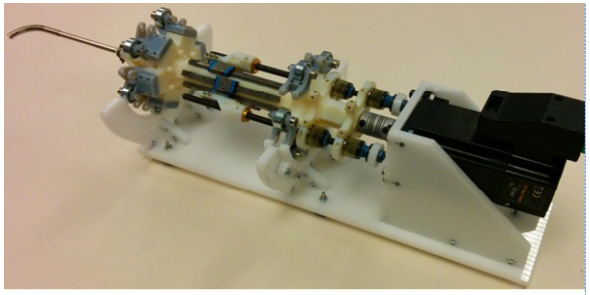


Project 6: Farshid Alambeigi

Mentors:
Dr. Mehran Armand, Ryan Murphy, Dr. Russell Taylor

Overview of Goals

- The BIGSS lab is developing a minimally-invasive surgical workstation to treat the osteolytic lesions using a snake like dexterous manipulator (SDM).
- The SDM will be positioned in the workspace by a robotic arm.
- The focus of this project is integrating the SDM with the robotic arm- which is a 6 DOF Universal Robot (UR5) - and position control of the tip of the SDM inside the lesion area.



Figures are property of BIGSS Lab.

Dependencies

- ✓ **Mechanical design:** ☺
  - 3D model of the SDM and electronic boards ☺
  - Machine shop and 3D printer for fabricating the interface parts ☺
- ✓ **Robots:**
  - UR5 robot and its stand ☺
  - SDM robot: I can use the BIGSS lab 2-D SDM. ☺
- ✓ **Kinematic model of SDM:** ☺
  - I will use the available model of Ryan Murphy.
- ✓ **Access to Mentors:** ☺
  - Weekly meeting with Dr. Armand and Ryan Murphy
  - Scheduled meeting with Dr. Taylor as needed

Deliverables status from last checkpoint and its update

Minimum

- Deriving and implementing the kinematic equations of UR5: ☺
- ➤Interfacing the SDM with UR5 (Mechanical design and fabrication): ☹ → ☺
- ➤Coupled inverse control of robots outside the body: ☺

Expected

- ➤Controlling the position of the coupled robots using virtual RCM when all of the SDM is in the body (Simulation and Implementation) : ☺ +😐 **(Ongoing)**

Added Deliverable

- ➤Submitting paper in IEEE Conference of Engineering in Medicine and Biology Society (EMBS'14) ☺

Maximum

- ~~➤Controlling the position of the coupled robots using virtual RCM when all of the SDM is not in the body (Simulation and implementation)~~
- ~~➤Modeling the kinematics of SDM using solid mechanics or beam theory~~

Management Plan

❖ **Detailed Task Schedule**

Task	9-Feb	16-Feb	23-Feb	2-Mar	9-Mar	16-Mar	23-Mar	30-Mar	6-Apr	13-Apr	20-Apr	27-Apr	4-May	
Preparing a 3-D model of the UR5	☺													
Deriving the Kinematics model of UR5	☺													
Simulation of the model in Simmechanics-Matlab	☺	☺												
Obtaining CAD models of Snake		☹	☹				☺							
Obtaining Kinematic model of Snake and working with it			☹	☺										
Literature survey for virtual fixture		☺	☺	☺										
Mechanical interface of snake to UR5			☹	☹										
Ordering required parts and actuators														
Fabrication of first coupled robot														
Simulation of the inverse kinematics of the coupled robots				☺	☺	☺	☺							
Working with and setting up the UR5 robot				☹	☹	☹								
Controlling the coupled robots (Minimum Deliverable)														
Simulation of virtual fixture (RCM point is not on the snake)						☺	☺	☺						
Submitting paper in IEEE EMBS Conference (Added Deliverable)								☺	☺					
Testing the algorithm on Robots (Expected Deliverable)											☹			
~~Simulation of virtual fixture (RCM point is on the snake)~~														
~~Testing the algorithm on Robots (Maximum Deliverable)~~														
Final report Presentation														

Submitting paper in IEEE EMBS Conference- April 07

Control of the Coupled Motion of a 6 DoF Robotic Arm and a Continuum Manipulator for the Treatment of Pelvis Osteolysis

Farshid Alambeigi[1], Ryan J. Murphy[1,2], Ehsan Basafa[1], Russell H. Taylor[3], *IEEE Fellow*, and Mehran Armand[1,2]

Abstract— The paper addresses the coupled motion of a 6 degrees of freedom robot and a snake-like dexterous manipulator (SDM) designed for the treat... behind the imp... arth... mult... Cent... robot... piece... our r... lesion...

SUBMITTED FOR REVIEW

I. INTRODUCTION

We have developed a Snake-like Dexterous Manipulator (SDM) for medical applications with a focus on orthopaedic surgery [1, 2]. One motivating application is the treatment of osteolysis (bone degradation) behind the well-fixed acetabular component of a total hip arthroplasty (THA). The

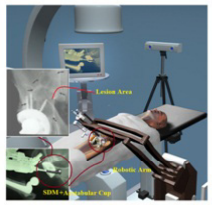
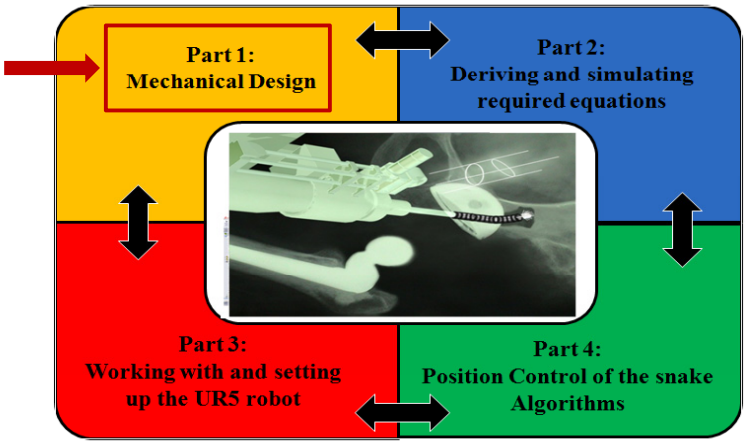


Figure 1. *Positioning of the SDM in workspace using a robotic arm and its access to the osteolytic lesion through the screw hole of the acetabular implant [1].*

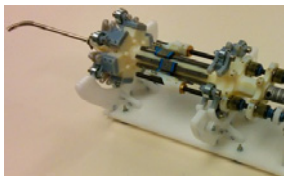
Technical Summary of Approach



Mechanical Design

The main purpose is to interface the SDM with UR5. This task involves:

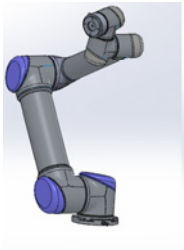
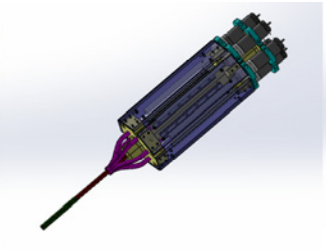
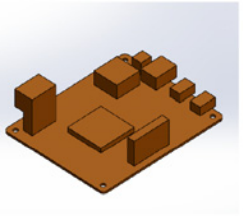
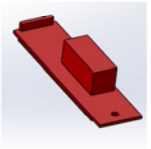
1. Preparing CAD models of UR5, Actuation Unit, and Electronic Boards
2. Mechanical interface of the SDM to the UR5 considering:
   - UR5 has a 5kg load limit
   - Not changing existing actuation unit
   - Considering work space of the UR5
   - Considering a place for electronic boards of actuation unit
   - Considering enough space for wiring between boards and motors



3. Fabrication of mechanical parts
4. Ordering required mechanical parts (Screws, nuts, Expansion fits)
5. Assembly

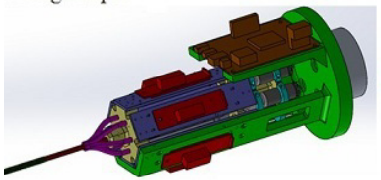
Mechanical Design

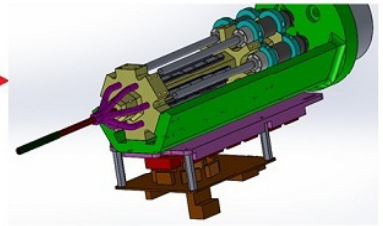
1. Preparing CAD models of UR5, Actuation Unit, and Electronic Boards:

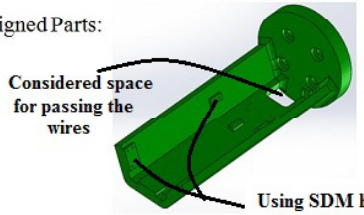
Mechanical Design

2. Design steps:


First Design


Final Design

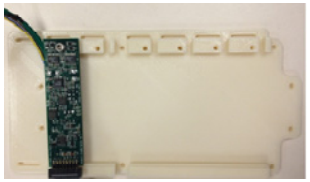
Designed Parts:



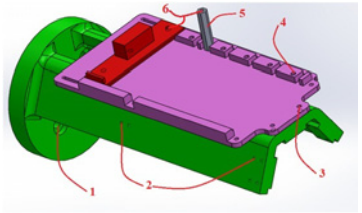

Electronic boards base

Mechanical Design

3. Fabrication of mechanical parts:

4. Ordering required mechanical parts (Screws, nuts, spacers, and Expansion fits)

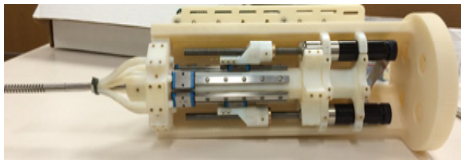
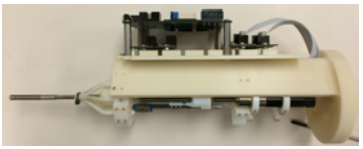
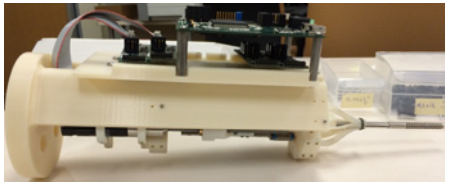
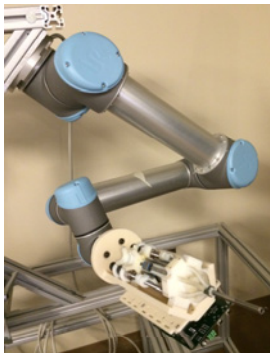


McMASTER-CARR

Line	Quantity	Product		Ships	Unit Price	Total Price
1	1 Pack	91772A871	18-8 SS Pan Head Phillips Machine Screw 0-80 Thread, 3/4" Length, Packs of 100	Monday morning	$8.95	$8.95
2	1 Pack	91239A321	Class 10.9 STL Button Head Socket Cap Screw M6 Size, 15 mm Length, 1 mm Pitch, Packs of 100	Monday morning	$11.46	$11.46
3	1 Pack	91772A110	18-8 SS Pan Head Phillips Machine Screw 4-40 Thread, 1/2" Length, Packs of 100	Monday morning	$4.45	$4.45
4	10 Each	91115A560	18-8 SS Female Threaded Hex Standoff 1/4" Hex, 1-1/4" Length, 4-40 Screw Size	Monday morning	$2.31	$23.10
5	1 Pack	92395A112	Brass Press-Fit Expansion Insert for Plastics w/o Flange, 4-40 Internal Thread, 3/16" Length, Packs of 50	Monday morning	$11.00	$11.00
6	1 Pack	91772A106	18-8 SS Pan Head Phillips Machine Screw 4-40 Thread, 1/4" Length, Packs of 100	Monday morning	$3.98	$3.98
7	1 Each	9619T52	Plastic Small-Parts Drawer Cabinet 26 Drawers, 20" W X 10-11/32" H X 6-3/8" D	Monday morning	$22.41	$22.41
					Merchandise	$86.35

Mechanical Design

5. Assembly:

Management Plan

- **Ongoing works:**
  - **Preparing required connectors and wiring between boards and motors**
  - **Controlling UR5 using Matlab and TCP/IP protocol**
  - **Implementing simulated algorithms**
  - **Preparing Final report**

Thanks for your attention

Questions??