



Training System for Minimally Invasive and Robot Assisted Surgery

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Outline

- Introduction
- Background of Problem
- Motivation
- State of the Art
- Our Project Summary
- Progress so far
- Other projects
- Acknowledgements

About the Team

- **School of Electrical Engineering & Computer Science, NUST**

- Dr Osman Hasan, Project Director
- Dr Muddassir Malik Co-PI,
- Dr Sohail Iqbal (PhD Surgical Robots)
- **Shamyl Bin Mansoor**

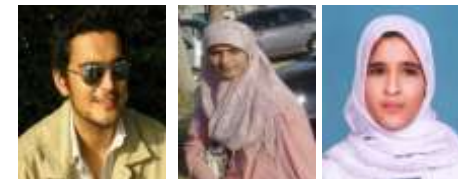


- **Abdul Afram**
- Zohaib Amjad (Software Engineer)
- Taimur Hassan (Mechanical Engineer)
- Hasan Sajid (Mechanical Team Lead)
- Sajid Nisar (Mechanical Design)
- Yasir Hasan (Project Coordinator)
- Bushra Sadia (Graduate Researcher)



- **Holy Family Hospital, Rawalpindi**

- Dr Asif Zafar, Professor of Surgery, (Co-PI)
- Dr Qasim Ali, Senior Registrar (Surgeon)
- Dr Faisal Murad, Senior Registrar (Surgeon)
- Dr Naeem Zia
- Dr Muhammad Shahzad Javid





Team (Cont)

SMART Lab

- Faculty
 - Shahid Razzaq
 - Asad Ali Shah
- Students
 - Iram Tariq (Full Time RA)
 - Ahsan Rahman
 - Wajahat Karim
 - Muhammad Yousif
 - Mohsin Nasir
 - Sheeraz Ahmad Memon
 - Hafiz Muneeb Ahmad
 - Adil Usman
 - Muhammad Waseem Pahnwar

SMART Lab

- Summer Internees
 - Almamoun Private University for Science & Technology, Aleppo, **Syria**
 - Imam Khomeini International University, **Iran**
 - Johannes Kepler University, Linz, **Austria**
 - Sultan Qaboos University, Muscat, **Oman**
 - Carnegie Mellon
 - Harvard



Background

- Conventional Open Surgery Vs Minimal Invasive Surgery

Open procedure incision

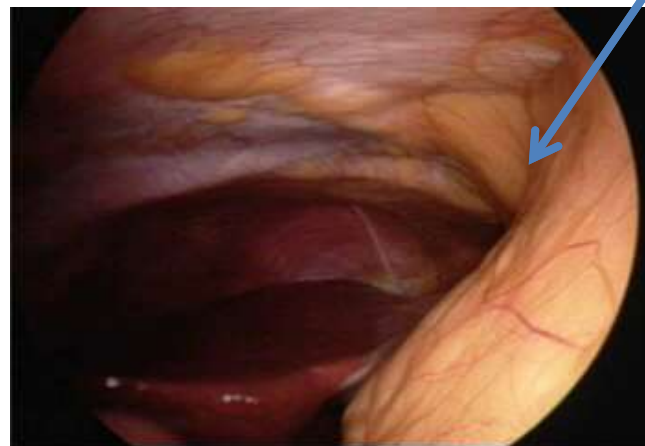
Laparoscopic incisions



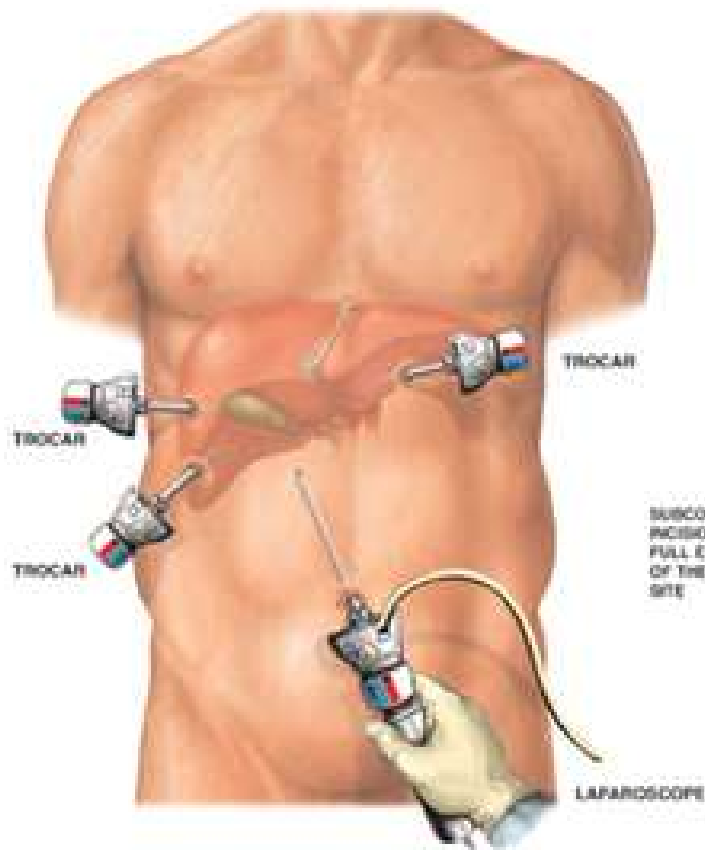
Conventional Surgery



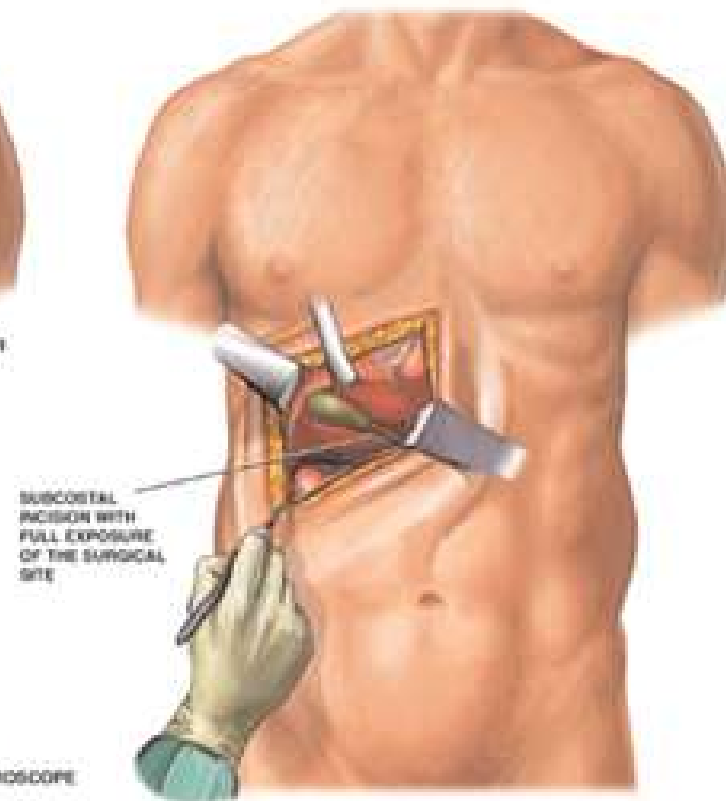
MIS



* Images courtesy of Dr Asif Zafar (Holy Family Hospital, Rawalpindi)



LAPAROSCOPIC CHOLECYSTECTOMY PROCEDURE



OPEN CHOLECYSTECTOMY PROCEDURE

Used in Laparoscopy



Current Methods

- Robots Assisted Minimal Invasive Surgery





Motivation

- Minimal Invasive Surgery is currently in vogue
- Operations once performed “open” are now done almost exclusively using laparoscopes
- The latest trend is to perform robots assisted surgery
- All these new skills require special training
 - Hand Eye Coordination
 - Navigation of Camera and Laparoscopic instruments in a confined space
 - Facilities limited for Pakistani Surgeons
 - Commercial Simulators are very expensive

State of the Art

ProMIS by Haptica, Ireland
LapSIM by ...

eden



(Basic Skills)

(Suture 3.0)

(Basic Skills 2.0)

Lap



operating room



Our Project

- Objectives
 - Developing a cost effective training system for Minimal Invasive Surgery
- Major Components
 1. **Virtual Reality Simulator for Minimal Invasive Surgery**
 2. **Training Robot for Robot assisted Minimal Invasive Surgery**
 3. **Haptic Input Device**
- Value Addition
 - Simulating Real Surgery Scenes recorded at Holy Family Hospital
 - Using open source tools making it cost effective
 - Haptic Interface with the Simulator
 - Developing basic and advanced exercises (Fundamentals of Laparoscopic Surgery (FLS) curriculum)



1. VR Simulator for MIS Surgery

- Major challenges
 - Modeling Human Anatomy
 - Real Vs Generated Models
 - Simulation of Volumetric Models
 - 3D not 2D simulation
 - Collisions between volumetric models
 - Visualization and real behavior
 - Simulating complex surgical scenarios



Approach

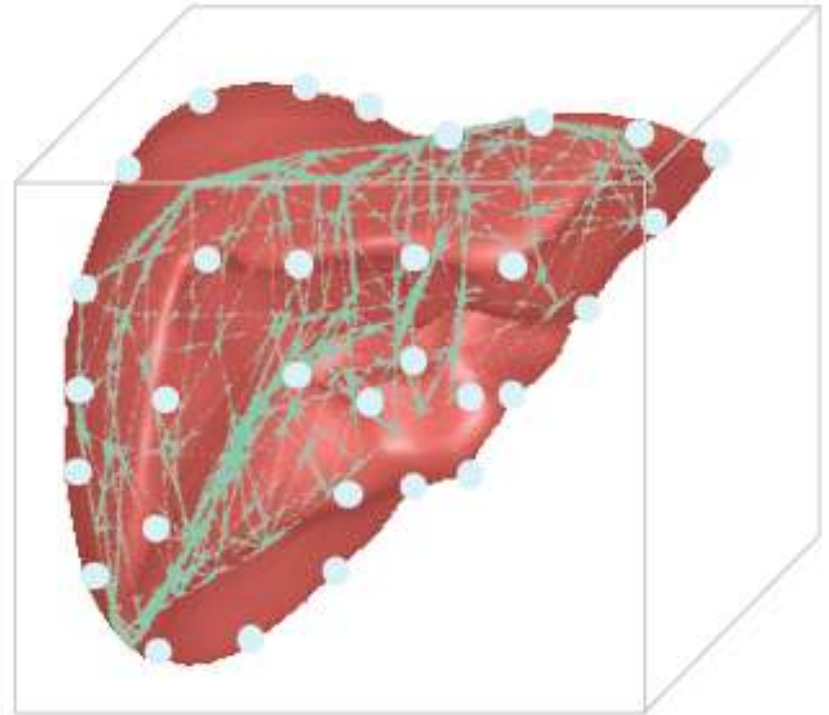
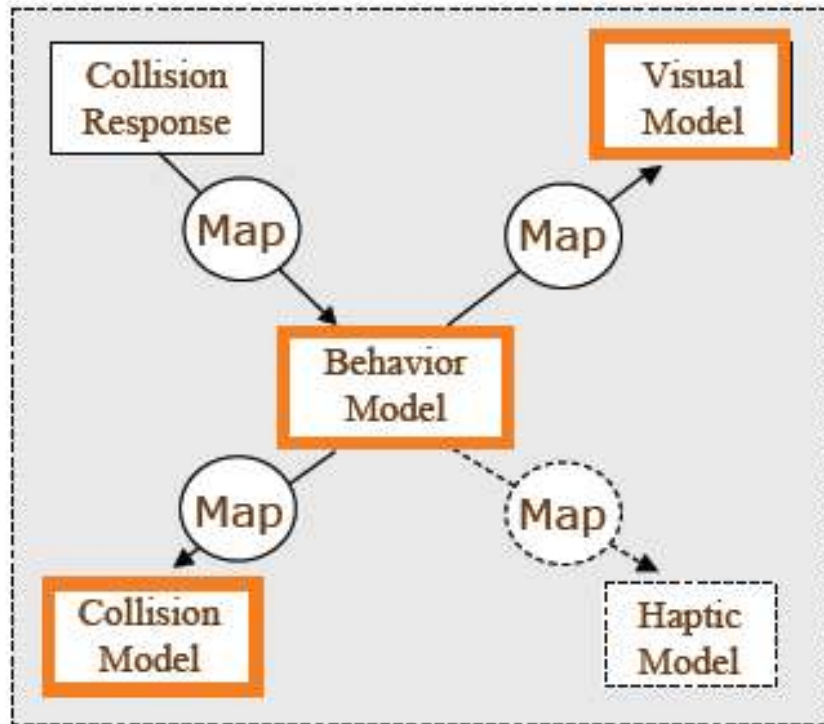
- Use Open Source
 - Using Simulation Open Framework Architecture (SOFA)
- Keep it simple and modular
 - Extending the functionality by adding new customized modules
- Improving on existing Systems
 - Simulating real scenarios (Developing Simulation Scenarios using Recorded Videos of actual surgeries)



Modeling in SOFA

- Mechanical Model
- Collision Model
- Visual Model
 - Each model can be designed independently
 - During run-time, consistency is maintained using mappings

Multimodal Representation



Simulation Examples



Peg Transfer.flv



LiverGrasp.flv



cholecystectomy simulator.flv - YouTube.flv



2. Training Robot for Robot Assisted MIS

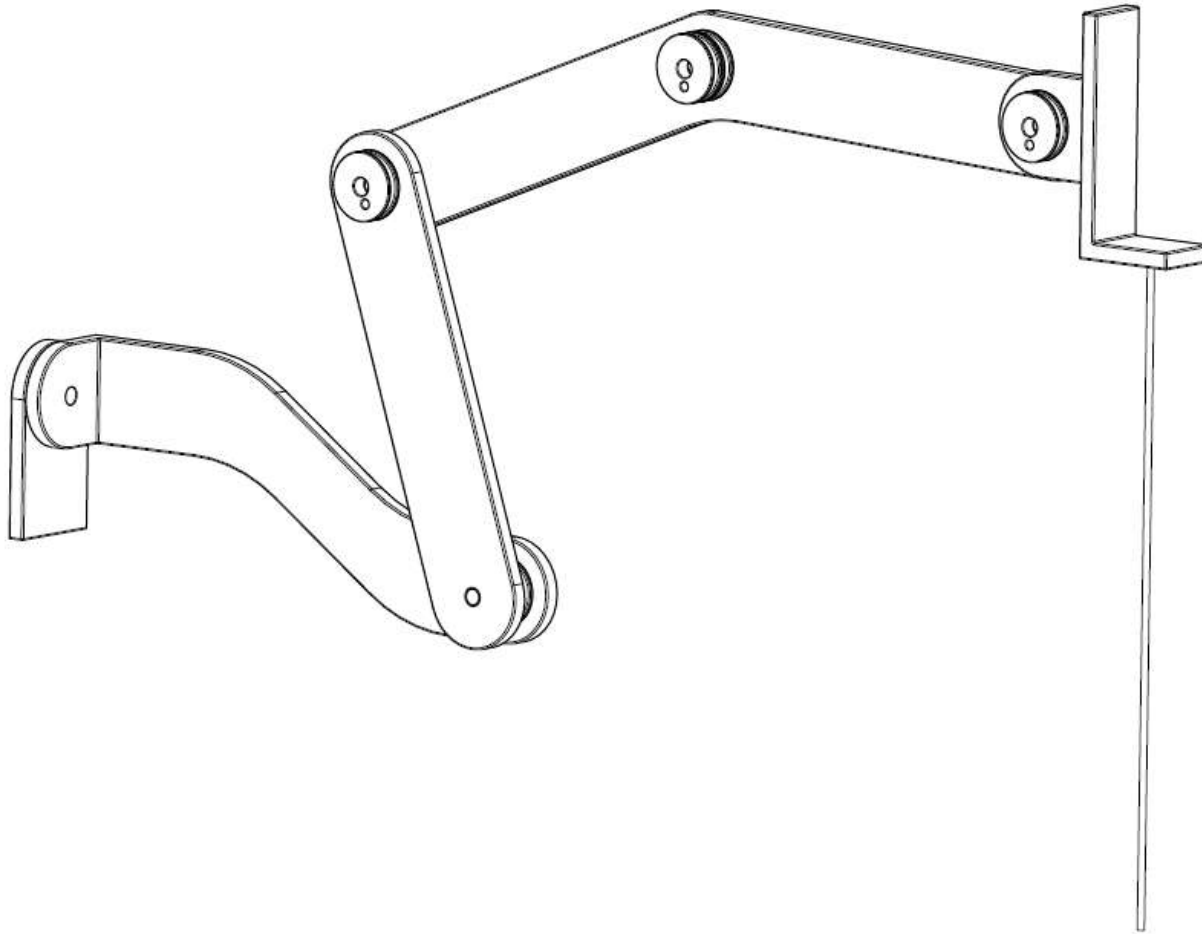
- Developing a training system to train surgeons for Robot Assisted Surgery
- Major Components
 - Robotic Arms
 - User Control
 - Tele-Operation



Approach

- Design for confined space
- Use existing Laparoscopic devices than design from scratch
- Able to switch different laparoscopic devices
- Multi-purpose?

Initial Prototype Modeling



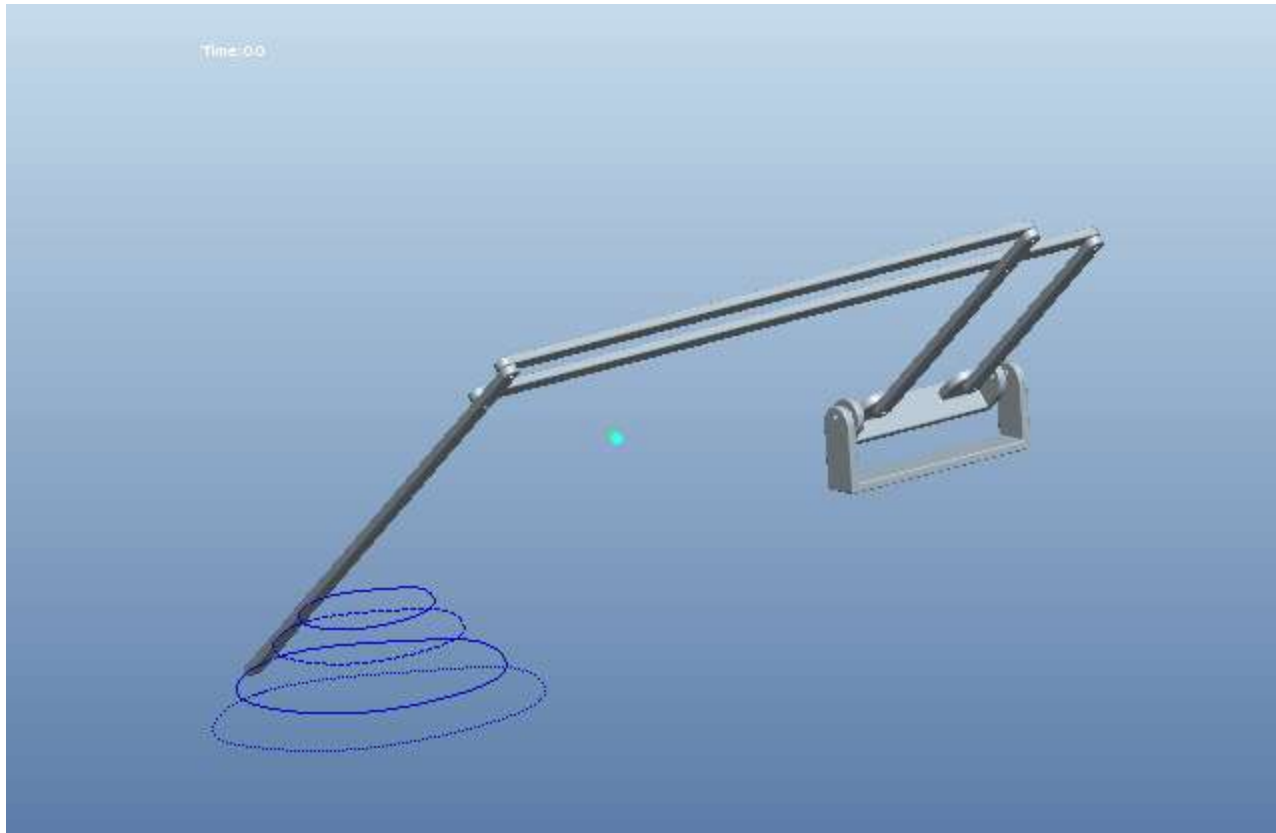


Video

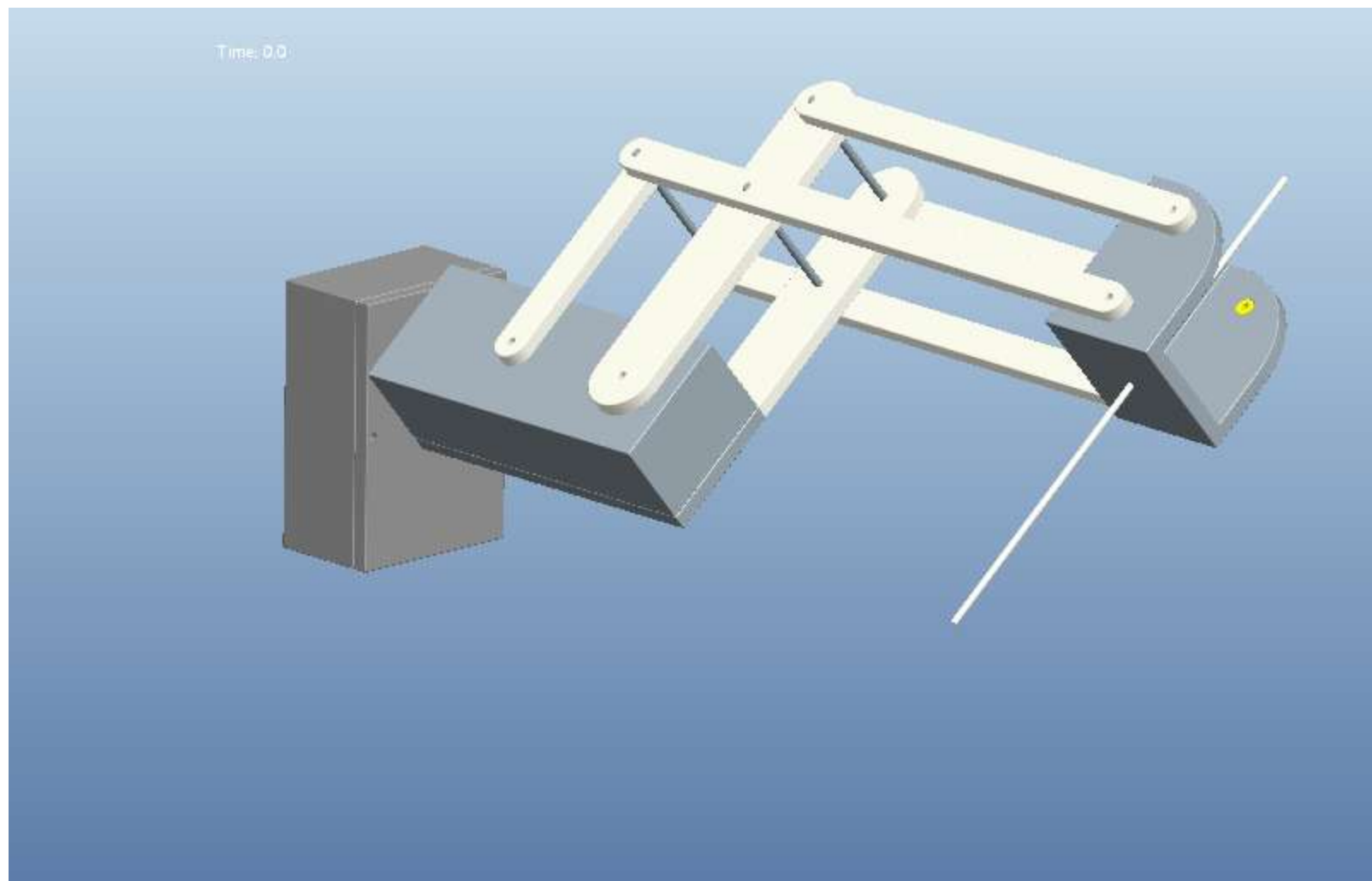


More prototype modeling

- Basic Parallelogram Mechanism



Even More Prototype modeling





Finally! First Prototype



Pegs Transfer Exercise.wmv - YouTube.flv

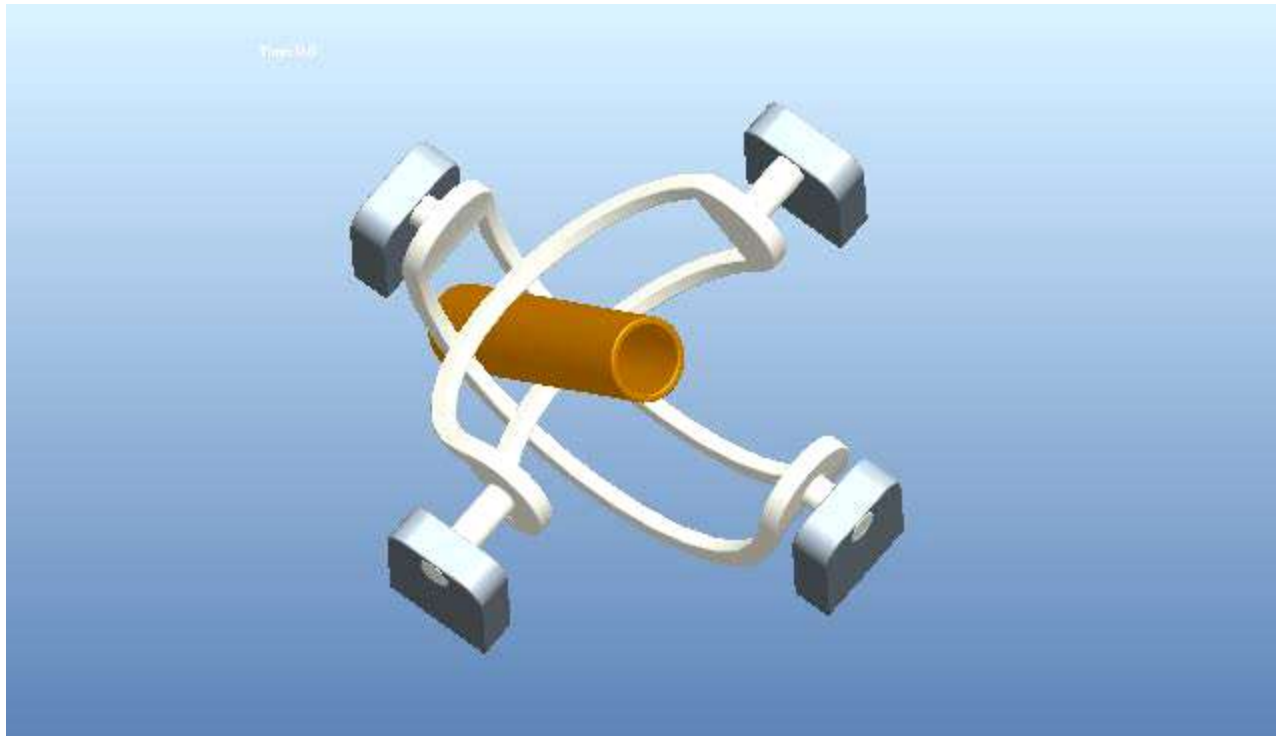
3. Haptic Input Device

- We wanted to use off the shelf Xitact
- Costs 40,000 Euros!
- So we'll make our own!





Prototype Modeling (work in progress)





Progress So Far

- 2 tools developed for SOFA
- Shared by SOFA developers on SOFA's official wiki pages, hosted by INRIA
- Paper submitted on usability study of Interface devices for virtual surgical simulations
- Prototypes developed



Some interesting facts

- Out of this project
 - 2 faculty
 - 4 Surgeons
 - 6 engineers
 - 2 Graduate students
 - 6 UG students
- Are learning as well as earning!
- 2 MS Thesis underway
- 1 PhD in Surgical Robotics also joins NUST



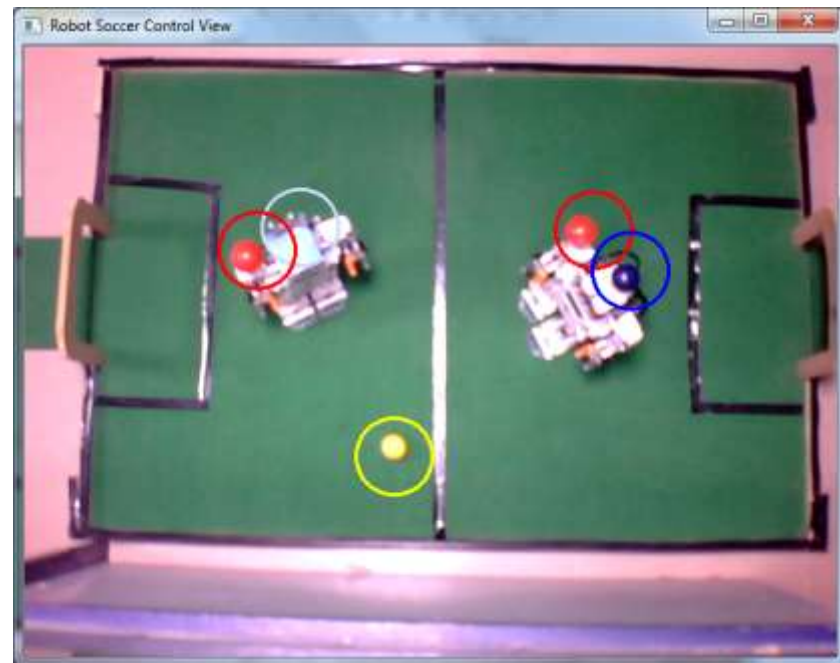
Money Matters!

- Market Size
 - The global robotic surgical market size is currently estimated to be **\$1 billion** *
- Target Customers
 - Hospitals, Holy Family Hospital (Rawalpindi Medical College)
 - Medical Colleges
 - Great Market potential in developing Mid-East, Asian and African Countries for our system

* Mohamed R. Ali, Jason J. Rasmussen. Journal of Laparoendoscopic & Advanced Surgical Techniques. February 2008, 18(1): 32-36.

Other Research at SMART Lab

- Robot Soccer framework for learning using LEGO Mindstorms





Other Research at SMART Lab

- Android Automation



SMART AUTOMATION.3gp - YouTube.flv



Some other Research Labs

- VisPro (Visual Image Processing)
- Conneckt (Wireless Sensor Networks)
- Wisnet (Wireless Sensor Networks)
- HL-7 (HL-7 Inter-operatibility Standards)
- Analog Mixed Signal Design Group



Acknowledgments

- **National ICT R&D Fund, Ministry of Information Technology, Govt. of Pakistan**
- Dr Asif Zafar, Holy Family Hospital
- Dr Arshad Ali, Principal-SEECS, NUST
- Dr Qasim Sheikh, Director Innovation, NUST
- School of Mechanical & Manufacturing Engineering (SMME), NUST
- **LUMS (For inviting us)**



Useful Links

<http://smart.seecs.nust.edu.pk>

<http://www.seecs.nust.edu.pk>

<http://www.sofa-framework.org>