Sponsor: Prof. Mian Li

Team 10

Team Member:
Niall Halloran
Zhiyuan Xiang
Jingying Wang
Wentao Yang
Minhao Jin

AR-Enabled Gesture Control of Robotic Arm I

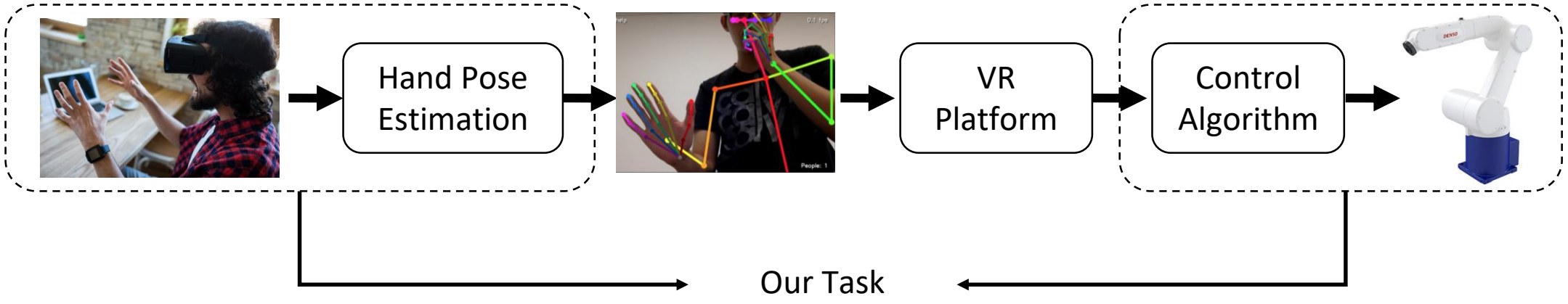
Design Review #1

Contents

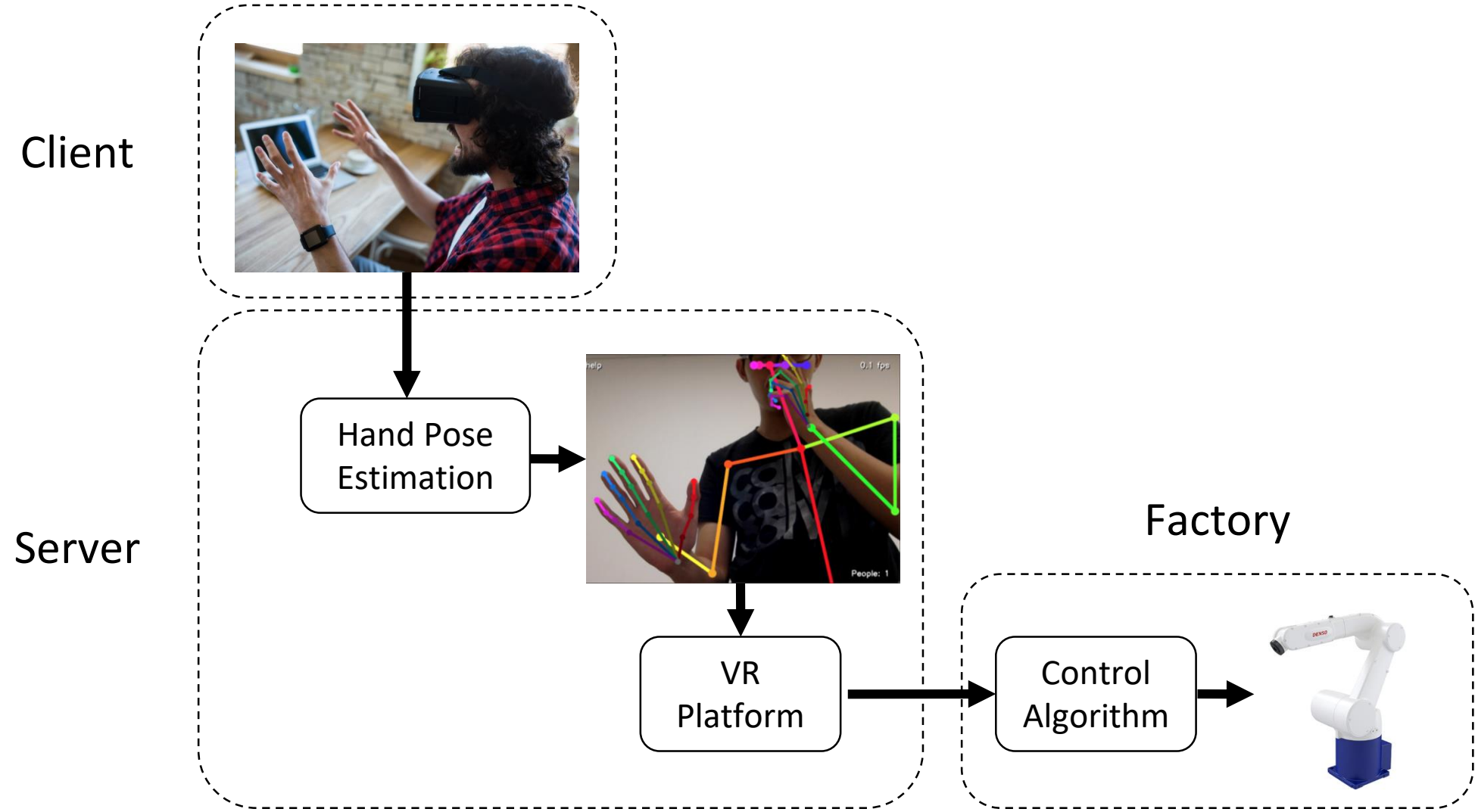
1. Overview of the Project

Overview of the Project

- Background: Future Factory
- Develop a gesture control method to control an industrial robot which can allow people to use the different gestures to control the activities of the industrial robot to deliver designed functions, which is compatible with the AR/VR part of this system.



Overview of the Project



Overview of the Project

Tasks to do:

- Hand Pose Estimation--------Minhao Jin, Zhiyuan Xiang, and Jingying Wang
- VR Platform Development
- Wireless communication
- Control Algorithm----------All team members
- Robotic Arm Installation-----Wentao Yang and Niall Halloran

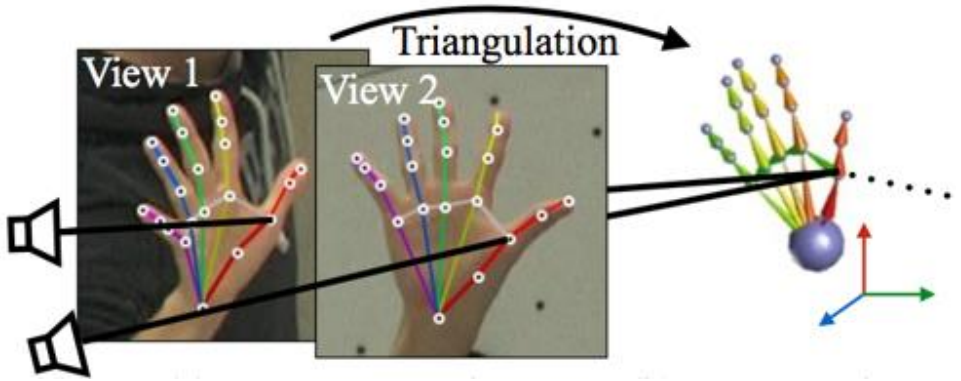
Engineering Specifications:

- Open-pose Hand Estimation
  - Accuracy: 62 mPA
  - Speed: real-time, 20 fps
- Control Algorithm and Robotic Arm
  - Accuracy: synchronous with virtual robotic arm, with millimeter-scale discrepancy
  - Speed: delay within 1~2 seconds

2. Tasks and Benchmark

2.1. Hand Pose Estimation

Hand Pose Estimation



2D hand pose estimation

Identify the hand pose in a single 2D picture

- Single camera system is enough
- The accuracy is susceptible to many factors

3D hand pose estimation

Generate a 3D model of the hands to form an accurate estimation of hand pose

- Can get a more accurate estimation
- Usually a multi-camera system is needed
- More computational power is required

Convolutional pose machines

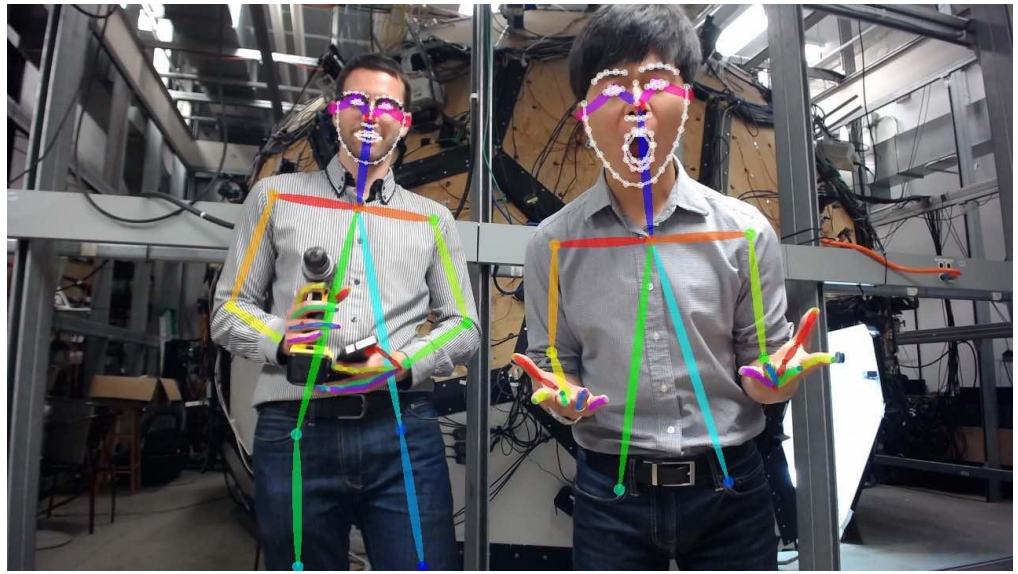
- A sequential architecture composed of convolutional neural network

Shih-En Wei, Varun Ramakrishna, Takeo Kanade, Yaser Sheikh; Convolutional Pose Machines, The IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2016, pp. 4724-4732
Tomas Simon, Hanbyul Joo, Iain Matthews, Yaser Sheikh; Hand Keypoint Detection in Single Images Using Multiview Bootstrapping, The IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2017, pp. 1145-1153

Hand Pose Estimation

MVIG-SJTU ALPHA POSE Pose Estimation

OpenPose



OpenPose: Realtime Multi-Person 2D Pose Estimation using Part Affinity Fields

Zhe Cao, *Student Member, IEEE,* Gines Hidalgo, *Student Member, IEEE,* Tomas Simon, Shih-En Wei, and Yaser Sheikh

OpenPose

- Robustness
- High accuracy
- Fast processing

Zhe Cao and Gines Hidalgo and Tomas Simon and Shih-En Wei and Yaser Sheikh, OpenPose: Realtime Multi-Person 2D Pose Estimation using Part Affinity Fields

2. Tasks and Benchmark

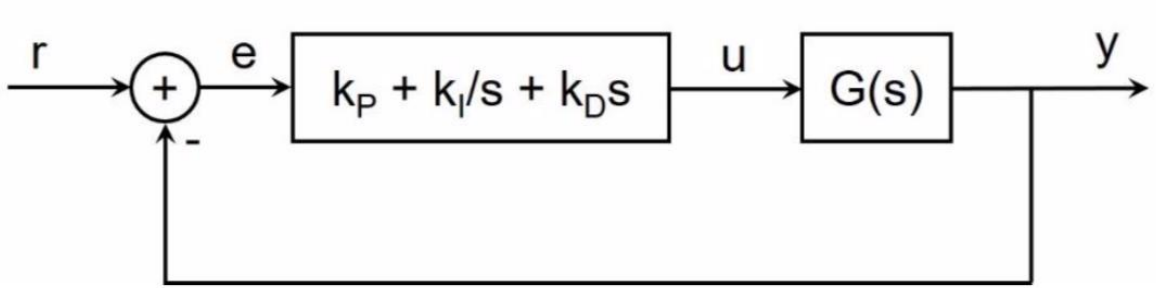
2.2. Control Algorithm

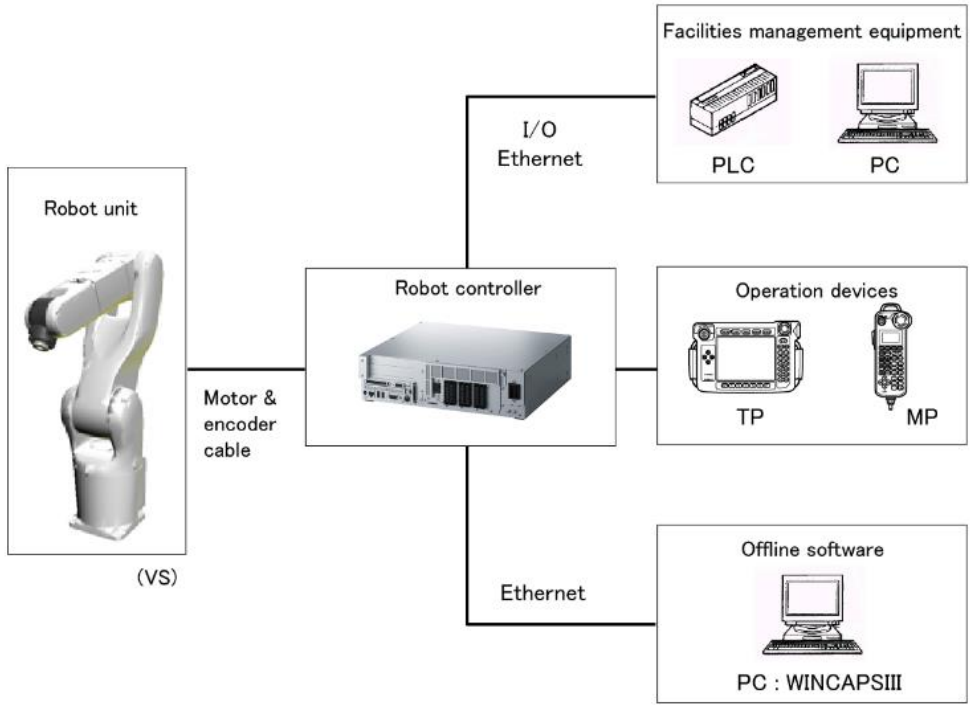
Proportional-intergral-derivative (PID) Control system

- A **P**roportional term to close the feedback loop
- An **I**ntegral term to assure zero error to constant reference and disturbance inputs
- A **D**erivative term to improve (or realize) stability and better dynamic response by performing “anticipatory” operation

$$D_c(s) = k_P + \frac{k_I}{s} + k_D s$$

$$e_{ss} = \lim_{s \to 0} s \cdot \frac{1}{1 + G \cdot \left(k_p + \frac{k_I}{s}\right)} \cdot \frac{1}{s} = 0$$





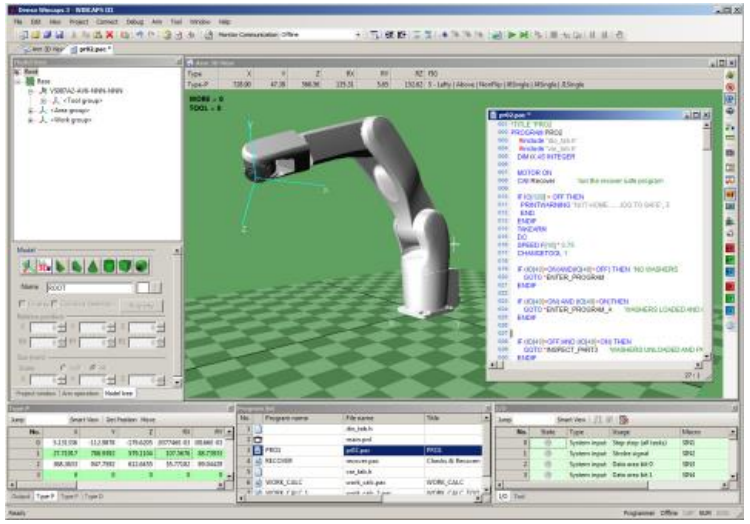
Franklin, G., Powell, J. and Emami-Naeini, A. Feedback Control of Dynamic Systems (8th Edition)

2. Tasks and Benchmark

2.3. Robotic Arm Installation

Robot arm operation

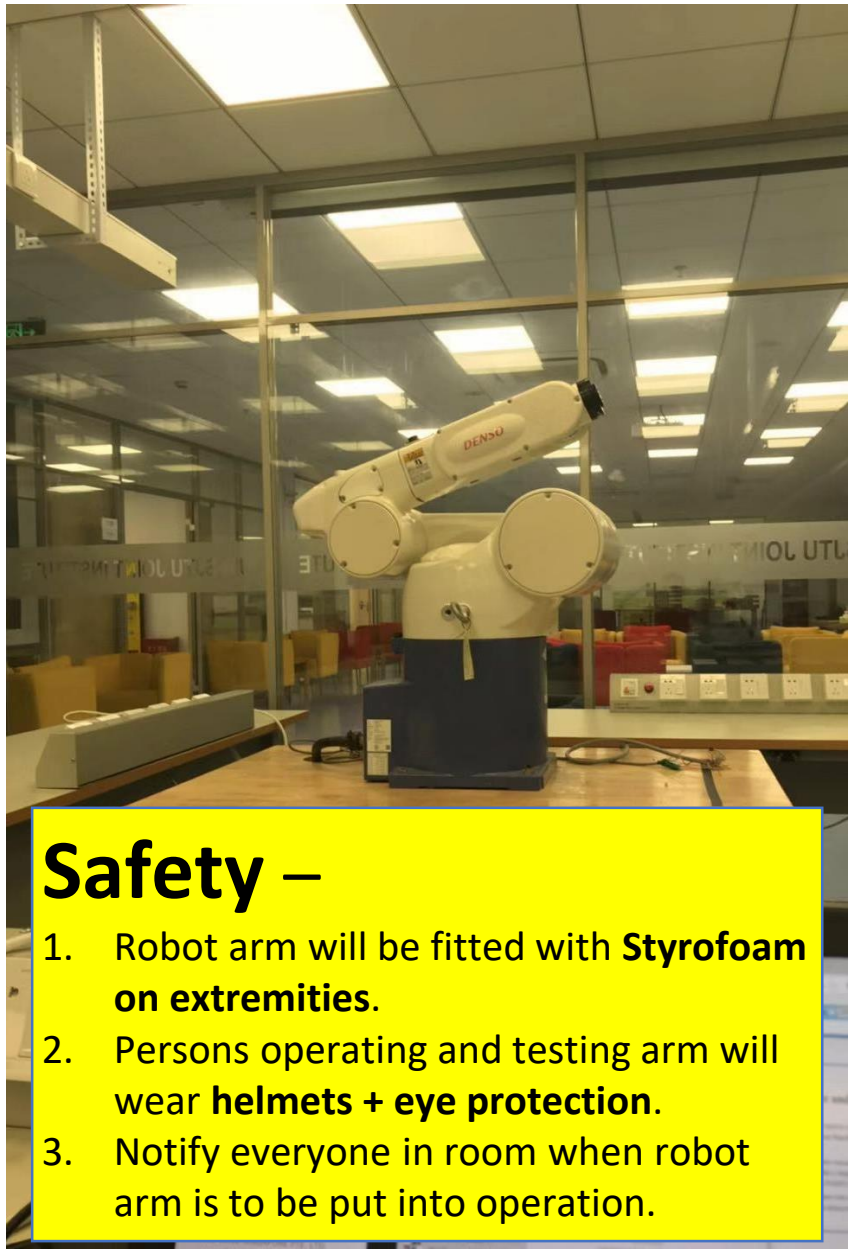
The DENSO VM6083 can be operated in multiple ways. From our literature study of Denso's robot series, we found that using their **WINCAPSIII** program will be the most suitable



Goal : To take inputs from the VR space, implementing location and gesture of the hand in WINCAPS and actively control the robot **in real time** relative to the user.

Method

- Receive part locations and send estimate coordinates of hand to WINCAPS > Move robot arm accordingly.
- Implement gesture statements in WINCAPS, when signal is received robot 'hand' will open/close/rotate.



Safety –

1. Robot arm will be fitted with **Styrofoam on extremities**.
2. Persons operating and testing arm will wear **helmets + eye protection**.
3. Notify everyone in room when robot arm is to be put into operation.

DENSO WAVE robot manual - "https://www.denso-wave.com/authupd/21032/20085_contents4.zip"

3. Social Value

Social Value

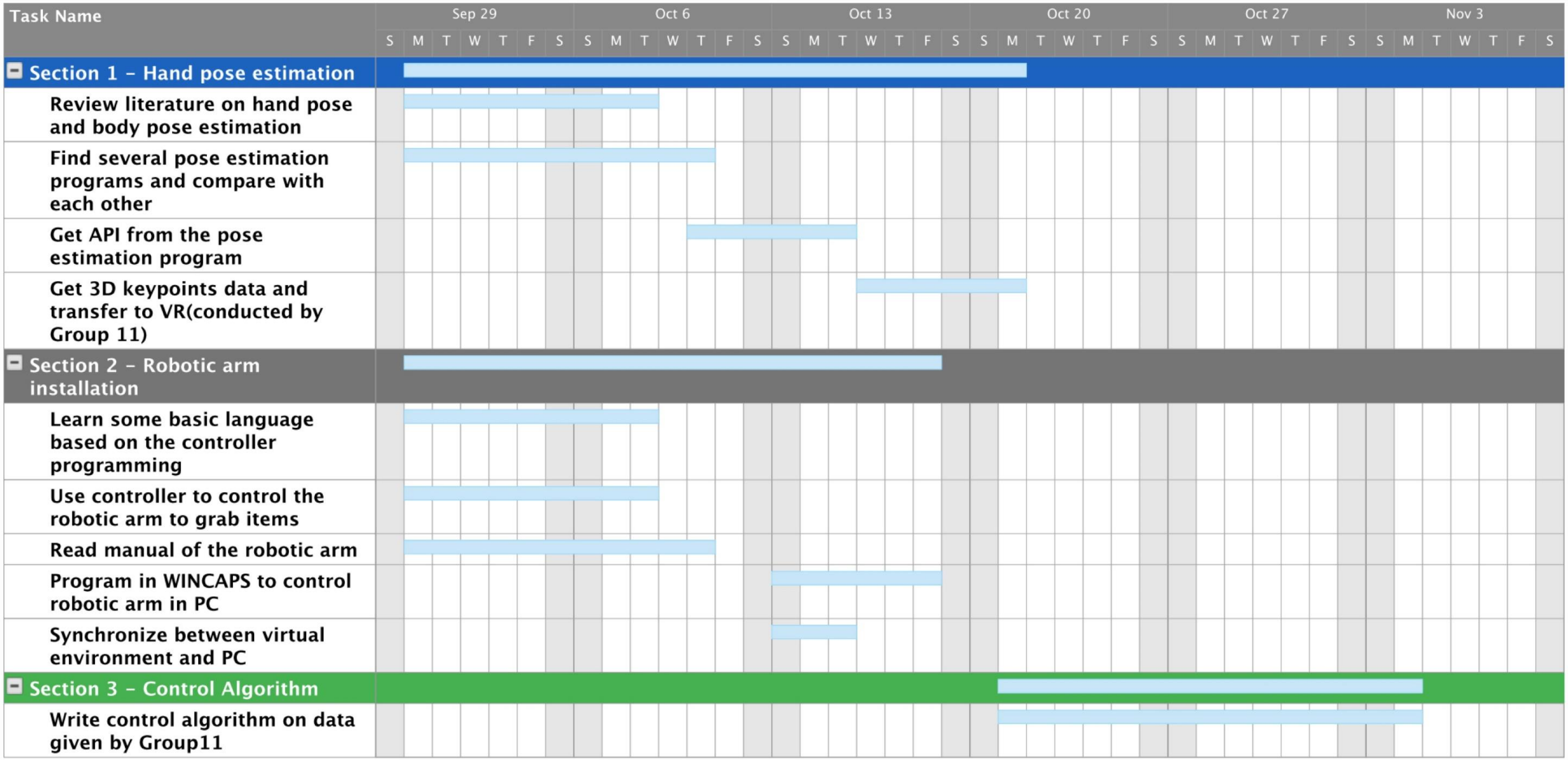
Remote control system

One person grabs a thing through VR system and robotic arm will also grab one thing in a remote factory.

- Convenient for user to handle emergency issues
- Suitable for very dangerous operations
- Intuitive to user
- Accessibility

4. Project Schedule

Schedule


Task Name
Sep 29
Oct 6
Oct 13
Oct 20
Oct 27
Nov 3
S M T W T F S S M T W T F S S M T W T F S S M T W T F S S M T W T F S S M T W T F S
1 Section 1 – Hand pose estimation
2 Review literature on hand pose and body pose estimation
3 Find several pose estimation programs and compare with each other
4 Get API from the pose estimation program
5 Get 3D keypoints data and transfer to VR(conducted by Group 11)
6 Section 2 – Robotic arm installation
7 Learn some basic language based on the controller programming
8 Use controller to control the robotic arm to grab items
9 Read manual of the robotic arm
10 Program in WINCAPS to control robotic arm in PC
11 Synchronize between virtual environment and PC
12 Section 3 – Control Algorithm
13 Write control algorithm on data given by Group11

Reference

Shih-En Wei, Varun Ramakrishna, Takeo Kanade, Yaser Sheikh; Convolutional Pose Machines, The IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2016, pp. 4724-4732

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