Team Baseline Plan

Project: E-12-MJON-021 Real-time Pose Estimation

Supervisor: Professor Jonathan Manton

Team:

1. *Matthew Yong (ID: 765 353)*
2. *Tsz Kiu Pang (ID: 965 374)*
3. *Yong Yick Wong (ID: 796 429)*

Date: 19 April 2020

Table of Contents:

Project Charter – E-12-MJON-021 Real-time Pose Estimation

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Author ID	765353; 965374; 796429
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Objective:

To design and test a simple interactive sound synthesis prototype system with real-time control using hand gestures and upper-body movements. This prototype system is used as a "Proof-of-Concept" for a Human-Computer Interaction in the context of audio synthesis.

Brief Description:

Pose estimation allows us to detect and estimate the location of human joints. In this project, we are using pose estimation to explore Human-Computer Interaction *(HCI)* by building a prototype of a real-time interactive system revolving audio synthesis, in the context of live music performance controlled by human gestures and movements.

The interactive system comprises three parts. The first part uses pose estimation to detect and to estimate the location of joints of our hands and upper body as observed by the computer via a webcam. The second part uses the locations detected to recognize a list of gestures such as fist and waving. The third part uses both joint locations and gestures recognized to control parameters, such as modulation index and frequency, of audio synthesizing techniques such as frequency modulation, which would be realized in a real-time audio synthesizing environment.

This prototype system is used as a "Proof-of-Concept" for a Human-Computer Interaction in the context of real-time audio synthesis.

Scope:

In-Scope:

Must -have
- Evaluation and final choice of open-source software for backend technologies: 2D-Pose Estimation, Gesture Recognition, and Real-time Audio Synthesizer.
- Design and testing the integration of all the technologies above either in parallel-pipelining or in a sequential flow.
- Build a library of hand and arm gestures to be recognized.
- Design of the Gesture Recognition on continuous-temporal gestures of the upper body.
- Design and testing of the mapping-and-control system to associate the gestures and the body movement to musical parameters uniquely.

Should-have:
- Extend the list of musical parameters to be controlled.
- Finger recognition from the Real-time Pose Estimation system.

Could-have:
- Enable 3D Pose Estimation for more expanded control, for example hand rotation.
- Simultaneous mapping-and-control of several musical parameters in real-time.
- Real-time audio processing with audio as input.
- Generate output as Musical Instrument Digital Interfaces (MIDI) Messages.
- Expand the audio synthesizing techniques to granular synthesis and physical modeling synthesis.

Out of Scope:

- Offline application on local machines.
- Provide an interface for users to record and map their own gestures to the musical parameters of interest.
- Extend the prototype to different speakers for the audio synthesize to enable other features for example 3D-audio effects.
- Improve the Pose Estimation algorithm to achieve a higher control rate or frame rate.

Stakeholders:

Supervisor / Sponsor:	
Professor Jonathan Manton	Department of Electrical and Electronic Engineering
Expert:	
Lucas James Barbuto	Melbourne School of Engineering *(MSE)*; IT Senior Systems Specialist
External Customers / Sponsors:	
N.A.	N.A.
Team Members:	
Matthew Yong	Project Manager
Tsz Kiu Pang	Project Manager
Yong Yick Wong	Project Manager

Timing of Major Milestones:

**For an elaborated timeline, please refer to the RACIX Matrix.*

1. Completion of the Project Charter	24/02/2020
2. Pose Estimation System completed and tested - The system should be able to measure joint locations of interests with a PCK (Percentage of Correct Key-points) of at least 80%.	04/05/2020
3. Gesture Recognition System completed and tested - The system should be able to recognize gestures in our list of gestures (please refer to the Scope section) with an accuracy of at least 80%.	04/09/2020
4. Music Synthesising System completed and tested - The system should be able to generate sound based on pre-configured parameters as well as parameters controlled by gestures, with an accuracy of at least 80%	11/09/2020
5. Final Re-design, Construction, and Testing completed - The system should at most have latency of about 5 seconds from our tests with various gestures and lighting.	30/09/2020
6. Endeavour Demonstration delivered	09/10/2020
7. Presentation (Oral Exam) given	30/10/2020
8. Final Report Submitted	09/10/2020

Success Measurement Criteria:

1. Functional Tests

- The system is able to detect joint locations of a pair of human hands and arms using a webcam in real-time.
- The system is able to recognize a library of recorded hands and upper body gestures in real-time.
- The recognized gestures as well as joint locations are streamed in real-time as data to an audio synthesizing environment, either Pure Data or SuperCollider.
- The recognized gestures as well as joint locations are used in real-time to control parameters in frequency modulation in the context of audio synthesizing, and in other synthesizing techniques if time permits.
- The parameters in the audio generated, which could be measured by a spectrogram, should reflect the parameters controlled by the gestures.

2. Quantitative Performance Tests

- The joint locations of interests should have a PCK (Percentage of Correct Key-points) of at least 80%.
- Maximum latency of 7.0 seconds for a physical gesture to be recognized. This latency should be measured from the end of performing the physical gesture, to the indication of the gesture being recognized by the gesture recognition part of the system.
- Maximum latency of 8.0 seconds for a physical gesture to induce an audible change in the corresponding audio parameter. This latency should be measured from the end of performing the physical gesture, to the audible change in the corresponding parameter(s) in the audio generated by the system. This audible change could be measured by a spectrogram.
- Gestures in our library of gestures should be recognized* with an accuracy of 80%, or better.

**(please refer to the Scope section.)*

Critical (Important) Success Factors:

1. Important Inputs

- A sufficiently powerful computing hardware from the Melbourne School of Engineering (*MSE)* to achieve real-time system:
    - Compute Unified Device Architecture (CUDA) supported Graphics Processing Unit (GPU) with at least 6.0 GB of free Random-Access-Memory (RAM) Memory.
    - or Open Computing Language (OpenCL) supported GPU of Vega-series Advanced Micro Devices Inc. (AMD) graphics card with at least 6.0 GB of free RAM Memory.
- Remote Connection Access to UniMelb server via Virtual Private Network (VPN).

2. Important Tasks and Actions

- To secure a Virtual Machine (VM) with computing requirements stated above from the Melbourne School of Engineering to have a shared development platform for the team.
- To set up and be able to run a real-time Pose Estimation (such as OpenPose) and Gesture Recognition Systems in the VM.

Major Risks and Treatments:

Risks	***Treatments***
No redundancies in the infrastructure should it fail - Since our application depends heavily on the virtual machine there would be a great impact on our project if the virtual machine fails or access is denied during the course of the project.	- Secure an alternative platform such as Google Cloud - Use our personal PC to run the application, which would require an alternative library of gestures that do not require locating exactly the fingers' joints to be recognized.
Gestures not accurately recognized - Occlusion and noisy image from webcam would reduce the accuracy of gesture recognition	- Improve the pose estimation algorithm for better accuracy in hand pose estimation in general - Use our own recorded hand poses as training data to the pose estimation algorithm for better accuracy in locating joints of our own hand poses - Choose gestures that are easier (with less occlusion) to be recognized when building our library of gestures (as stated in the Scope section)
Unfamiliarity with gesture recognition - Since our team is not particularly familiar with gesture recognition, there could be unforeseeable scope creep associated with it, which might require extra time to be dealt with.	- Familiarise ourselves with gesture recognition at the early stage of our project, so that if scope creep does appear, it could be dealt with earlier and the project timeline could be modified earlier if necessary.

Overall Probability of Technical Success	85% Pose Estimation and Gesture Recognition is well known in theory, but not completely familiar to the Project Team - Challenging Development.

Cost – Budgetary Estimate:

Item/Category	***Number***	***Unit Cost***	***Subtotal***
Virtual Machine *(University Resource)*	1920 hours	$1.08 per hour	$2000.00
Hours (students)	200 hours x 3 =600	$100 per hour	$60,000.00
Hours (supervisor - Professor Jonathan Manton)	25 hours	$200 per hour	$5,000.00
Hours (expert - Lucas)	8 hours	$200 per hour	$1,600.00
		Total Cost:	$68,600.00

Signatures:

Role	***Name***	***Signature***	***Date***
Supervisor	Professor Jonathan Manton		
Team Member	Matthew Yong	Matthew	19 April 2020
Team Member	Tsz Kiu Pang	Tsz Kiu	19 April 2020
Team Member	Yong Yick Wong	Yick	19 April 2020

References:

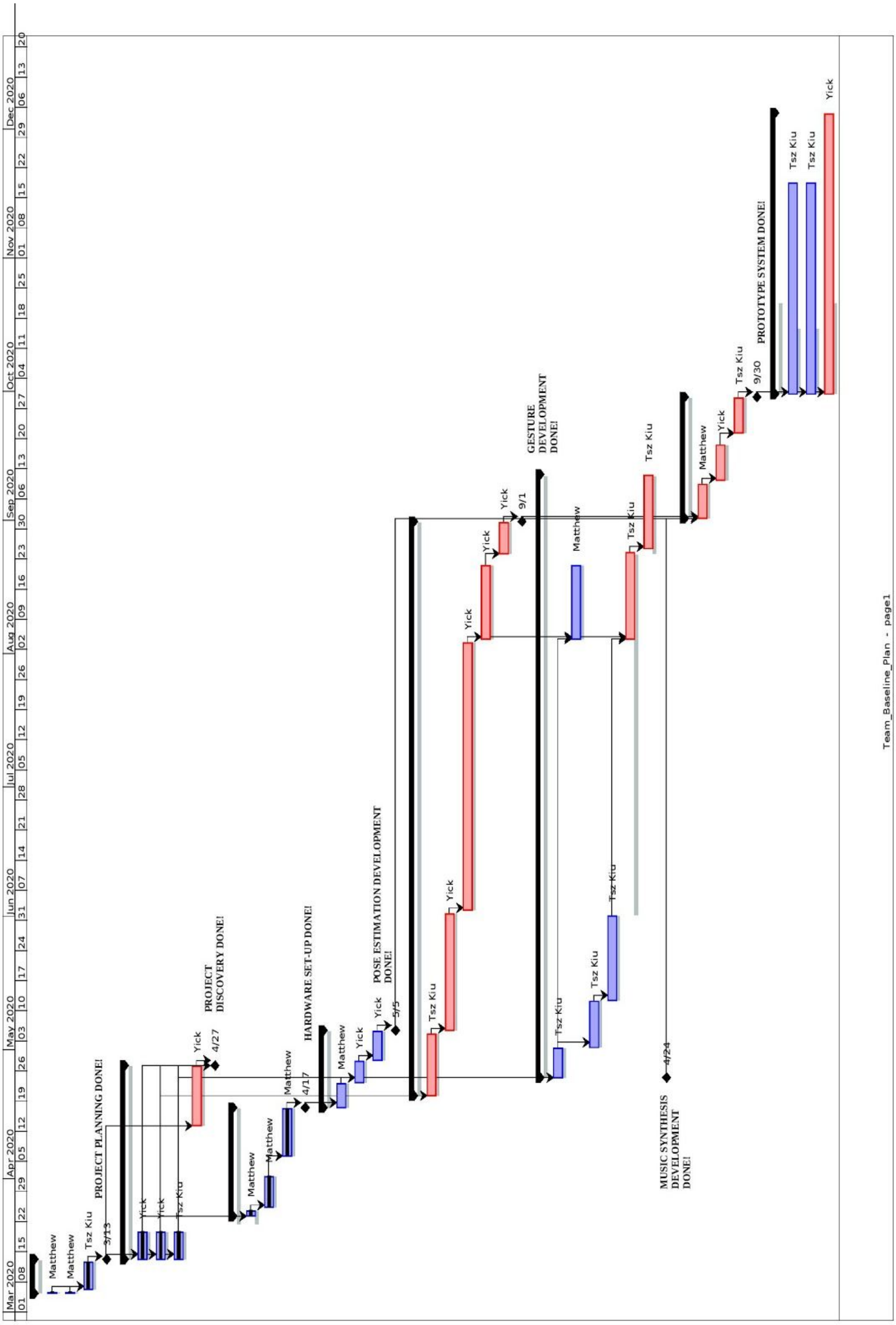
Document	***Version No.***	***Date***
Brief Description of Project (Real-time Pose Estimation)	1.0	02 March 2020
Skeleton Charter by Bob Warfield	1.3	01 March 2019
ENGR90037 Lecture Material: Capstone Project Management Lecture 01, Week 03	1.0	17 April 2020
Pose Estimation Definition: https://en.wikipedia.org/wiki/Articulated_body_pose_estimation	1.0	June 2018
Research Paper: "Neural Networks for Mapping Hand Gestures to Sound Synthesis Parameters" Author: "Paul Modler" Source: http://www.music.mcgill.ca/~mwanderley/Trends/Trends_in_Gestural_Control_of_Music/DOS/P.Mod.pdf	1.0	September 1998
Google Compute Cloud Virtual Machine Pricing https://cloud.google.com/compute/all-pricing	1.0	April 2020

Gantt Chart

Note*:

- The Critical Paths are indicated in RED.
- Tasks have been excluded in the Chart. Please refer to the RACIX Matrix.
- Milestones are indicated by diamond symbols.

**With reference to the Gantt Chart.*


Mar 2020
Apr 2020
May 2020
Jun 2020
Jul 2020
Aug 2020
Sep 2020
Oct 2020
Nov 2020
Dec 2020
PROJECT PLANNING DONE!
3/13
PROJECT DISCOVERY DONE!
4/27
HARDWARE SET-UP DONE!
4/17
POSE ESTIMATION DEVELOPMENT DONE!
5/5
GESTURE DEVELOPMENT DONE!
9/1
MUSIC SYNTHESIS DEVELOPMENT DONE!
4/24
PROTOTYPE SYSTEM DONE!
9/30
Matthew
Yick
Tsz Kiu
Team_Baseline_Plan - page1

RACIX Matrix

Note*:

- “A’ indicates who is accountable for the Task.
- “R” indicates who is responsible for the Task.
- “C” indicates whether the supervisor needs to be consulted.
- “X” indicates signed-off.
- Resource-Names are equivalent to “A”, but it’s the Software’s Feature.
- Stakeholders:
    - Supervisor: Professor Jonathan Manton *(Jonathan)*
    - IT Senior System Specialist: Lucas James Barbuto *(Lucas)*

**With reference to the RACIX MATRIX.*

No.	Tasks	Duration (days)	Start	Finish	Predecessors	Matthew	Tsz Kiu	Yick	Jonathan	Lucas (IT)
2	**Project Planning**	8	Thu, 5/3/20	Fri, 13/3/20	-	-	-	-	-	-
3	Plan Project Management and Collaboration Tools	1	Thu, 5/3/20	Fri, 6/3/20	-	A	R	R	-	-
4	Setting up Meeting Logistics	1	Thu, 5/3/20	Fri, 6/3/20	-	A	R	R	C	-
5	Plan Project Proposal	7	Fri, 6/3/20	Fri, 13/3/20	3,4	R	A	R	I	-
6	*Project Planning Done!*	0	Fri, 13/3/20	Fri, 13/3/20	5	-	-	-	X	-
7	**Project Discovery**	42	Fri, 13/3/20	Fri, 24/4/20	-	-	-	-	-	-
8	Find, identify and evaluate the open source Pose Estimation	7	Fri, 13/3/20	Fri, 20/3/20	6	R	R	A	-	-
9	Find, identify and evaluate the Gesture Recognition Techniques from literatures and open	7	Fri, 13/3/20	Fri, 20/3/20	6	R	R	A	-	-
10	Find, identify and evaluate the open source Music Sythesis Software	7	Fri, 13/3/20	Fri, 20/3/20	6	R	A	R	-	-
11	Documenting Team Baseline Plan (Assignment 1)	11	Mon, 13/4/20	Fri, 24/4/20	6	R	R	A	X	-
12	*Project Discovery Done!*	0	Fri, 24/4/20	Fri, 24/4/20	8,9,10,11	-	-	-	I	-
13	**Hardware Set-Up**	20	Sat, 21/3/20	Fri, 10/4/20	-		-	-	-	-
14	Requesting for Virtual Machine from Melbourne School of Engineering – Information Technology Support	4	Sat, 21/3/20	Wed, 25/3/20	8	A	R	R	I	C
15	Installing software environment for Pose Estimation to run on	8	Wed, 25/3/20	Thu, 2/4/20	14	A	R	R	-	C
16	Setting up Audio and Video live streaming	4	Mon, 6/4/20	Fri, 10/4/20	15	A	R	R	-	C
17	*Successfully run pose estimation program!*	0	Fri, 10/4/20	Fri, 10/4/20	16	-	-	-	I	-
18	**Pose Estimation System Development**	24	Fri, 10/4/20	Mon, 4/5/20	-	-	-	-	-	-
19	Develop communication system between Pose Estimation and Gesture Recognition Program	5	Fri, 10/4/20	Wed, 15/4/20	17	A	R	R	-	-
20	Reduce pose estimation GPU consumption down to GPU Specifications	3	Wed, 15/4/20	Sat, 18/4/20	19	R	R	A	-	I
21	Run tests and check accuracy of output keypoints	16	Sat, 18/4/20	Mon, 4/5/20	20	R	R	A	-	-
22	*Pose Estimation Algorithm Done!*	0	Mon, 4/5/20	Mon, 4/5/20	21	-	-	-	I	-
23	**Gesture Recognition System Development**	137	Mon, 20/4/20	Fri, 4/9/20	-	-	-	-	-	-
24	Defining a list of workable gestures to map using keypoints	11	Mon, 20/4/20	Fri, 1/5/20	9	R	A	R	-	-
25	Finding and creating training datasets of human body gestures	21	Fri, 1/5/20	Fri, 22/5/20	24	R	R	A	-	-
26	Creating a software system to recognize human gestures with Artificial Intelligence	77	Fri, 22/5/20	Fri, 7/8/20	25	R	R	A	-	-
27	Running tests to ensure both pose and gesture programs meet GPU specifciations	14	Fri, 7/8/20	Fri, 21/8/20	26	R	R	A	C	C
28	Running tests datasets on Gesture Program to observe accuracy	14	Fri, 21/8/20	Fri, 4/9/20	27	R	R	A	C	-
29	*Gesture Recognition System Done!*	0	Fri, 4/9/20	Fri, 4/9/20	28	-	-	-	I	-
30	**Music Synthesis System Development**	76	Fri, 24/4/20	Fri, 11/9/20	-	-	-	-	-	-
31	Choosing a real-time audio synthesising software based on the result of Task 10 and further experimentation	4	Fri, 24/4/20	Tue, 28/4/20	10	R	A	R	-	-
32	Developing a communication system between Gesture and Music program	14	Fri, 7/8/20	Fri, 21/8/20	26,31	A	R	R	-	-
33	Find, identify and document audio-synthesising techniques from literatures	7	Mon, 20/4/20	Mon, 27/4/20	-	R	A	R	-	-
34	Defining Musical Parameters to Control	16	Mon, 20/4/20	Wed, 6/5/20	33	R	A	R	-	-
35	Creating a Gesture to Musical Parameter Control System	20	Tue, 4/8/20	Mon, 24/8/20	34	R	A	R	-	-
36	Running tests to ensure the generated audio reflects the parameters controlled by gestures	15	Thu, 27/8/20	Fri, 11/9/20	35	R	A	R	C	-
37	*Music Synthesis System Done!*	0	Fri, 11/9/20	Fri, 11/9/20	36	-	-	-	I	-
38	**Integrating into Single Prototype System**	21	Fri, 4/9/20	Fri, 9/10/20	-	-	-	-	-	-
39	Testing Live streaming output of each subsystem	7	Fri, 4/9/20	Fri, 11/9/20	22,29,37	A	R	R	-	-
40	Complete Tests based on standard from a defined rubric	7	Fri, 18/9/20	Fri, 25/9/20	39	R	R	A	C	-
41	Documenting test results	7	Fri, 2/10/20	Fri, 9/10/20	40	R	A	R	I	-
42	*Prototype System Done!*	0	Fri, 9/10/20	Fri, 9/10/20	41	-	-	-	I	-
43	**Project Presentation**	21	Fri, 9/10/20	Fri, 30/10/20	-	-	-	-	-	-
44	Endeavour Exhitbition	7	Fri, 9/10/20	Fri, 16/10/20	42	R	A	R	X	-
45	Oral Presentation	14	Fri, 30/10/20	Fri, 13/11/20	42	R	A	R	X	-
46	Final Report	21	Fri, 9/10/20	Fri, 30/10/20	42	R	R	A	X	-

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