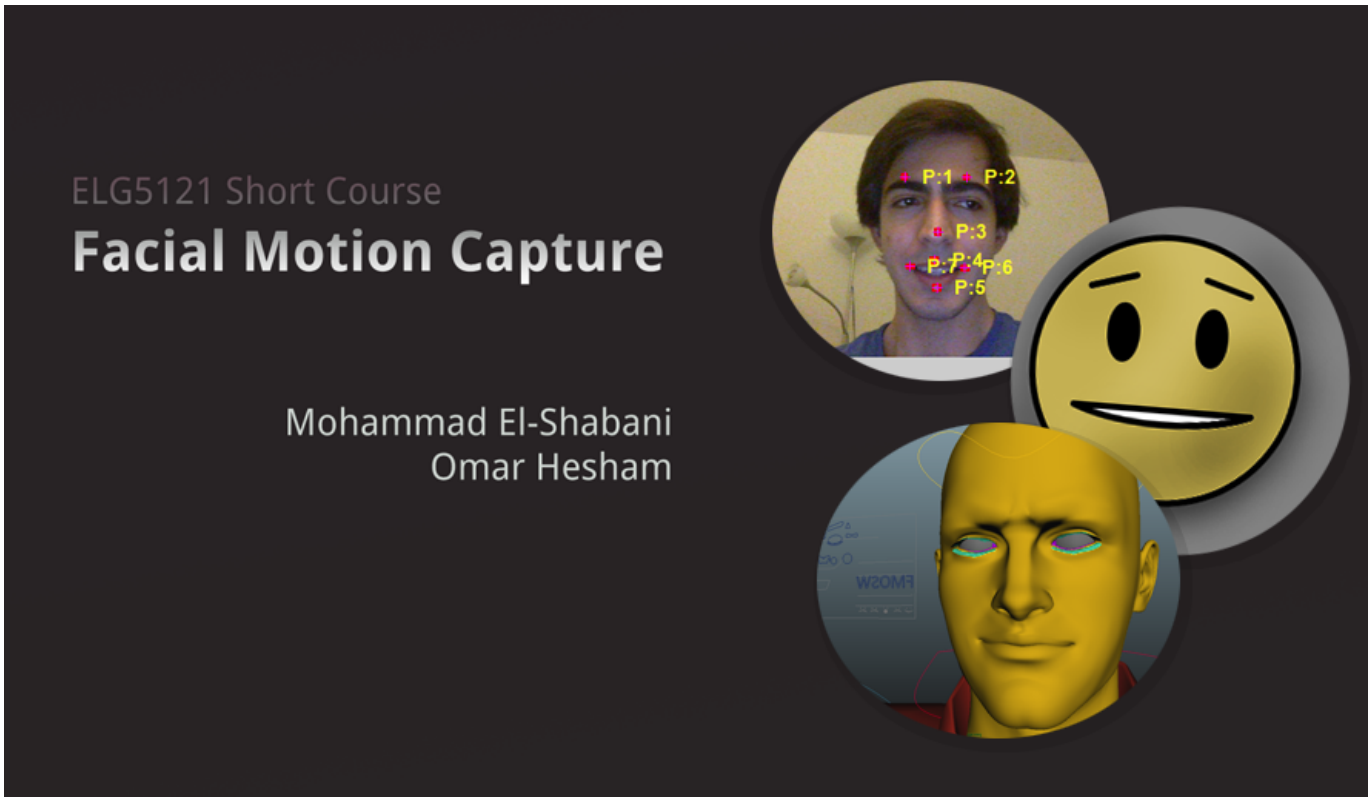
ELG5121 Project Report

Mohammad El-Shabani [5123975] & Omar Hesham [100695742]

Description - In this document, we will outline the steps taken to develop the short course as we originally intended in our proposal, including the software used, and any scheduling/organization documents we relied on.

1. Introduction

For this project, we developed a short course on the concepts and tech behind Facial Motion Capture. Overall the project is a two-parter: a conceptual video series, and a practical programming tutorial. We believe we have met the goals we set out initially in our Proposal doc (shown below), and are grateful for the experience of working together and learning something new.



Submission content:

- **Project Demo (~2 minutes):** ProjectDemo.mp4
- **Website files:** index.htm (start here), code.htm, about.htm
  - Note: local web files will *not* load youtube embedded frames without a properly configured local server. Hence, please view the same files as uploaded at the following mirror:
    - http://www.omarhesham.com/elg5121/
- **Video files:** VideoA_Greeting, VideoB_Intro, VideoC_Pipeline
- **Source code files:**
  - Matlab: faceTrack.m, faceplacment
  - Processing: drawFace.pde

2. Design Document

a. Project Proposal [Approved Feb 1, 2015]

ELG5121 Project Proposal

January 2015
Submitted to Prof. Abdulmotaleb El Saddik

Group Members

- ❑ Mohammad El-Shabani [University of Ottawa - 5123975]
- ❑ Omar Hesham [Carleton University - 100695742]

Topic Description

We intend to create a short course (topic #1) on the concept and technology behind "Facial Motion Capture". We'll utilise our combined skillset to use whatever tech necessary (video, flash, web, etc.) to present the material in a fun and engaging, possibly interactive, educational module.

Here's a rough outline of its content:

- **Intro**: a brief video introducing Facial Mocap tech in general and its categories (procedural, marker-based, markerless) and possible applications (communication, film & gaming, medical, etc.). About 2-3 minutes long.
- **Focus on marker-based mocap** (**example**): a longer video detailing the technical specifics and recent advancements in marker-based facial mocap. About ~10 minutes long.
- **Mocap Tools Directory:** a comprehensive listing of currently available commercial and academic tools (software/hardware) for facial mocap development. Useful for those who want to pursue the topic further.
- A neat little **webpage** to contain all that.

As with any project proposal, this is a preliminary plan that is subject to modification as the term progresses. Any changes will be documented in the final report.

b. Research and Ideas

For the first week, we set out to do background research separately, in order to freely explore the topic and maybe arrive at discoveries that the other member hadn't thought of before. This worked well, and we ended up with extensive draft notes about the topic as a whole. Eventually we were able to come up with the scheme as we described in the Project Demo video: half conceptual videos, and half practical programming. We thought this would strike a balance, especially considering our tech savvy **target audience: ELG5121 classmates.**

The following are snippets from our draft notes (disclaimer: we do not claim authorship on all of these notes, as some of them were lifted verbatim from their source for the purpose of our internal study and discussion, and not for any form of public publishing)

i. Sample of draft notes from Mohammad

some resistance. For example, "Animation is about creating an illusion of motion that doesn't otherwise exist. (Motion capture) doesn't involve the same artistic input and creativity." [3] . This is no longer the case; in the 2006 academy awards, two out of three nominees for best-animated feature used motion capture. [2]

2- Video Games:

As in filmmaking, motion capture is used in video games for realistic rendering of character movement but capturing that of actors and synchronizing characters to that data. This is used in sports video games, martial arts, shooting, and generally any video game that synthesizes human characters.[1]

Figure 1: Performance movement capture in video games; image from: http://news.boisestate.edu/update/2011/01/21/photo-of-the-week-%E2%80%94-jan-21/

3- Biomechanics Research

The birth of motion capture applications was in Biomechanics research. The study of human locomotion drove the initial development of motion capture systems. Pioneering attempts to understand human locomotion include Marey and Muybridge [4], where photographic techniques were used to quantify observations. This field is clinically known as Gait Analysis, which means the study of animal locomotion.

ii. Sample of draft notes from Omar

ELG5121 Project - Background Notes [Omar]

- Primarily an educational module.
- Introduce state of the art and categories of facial mocap: optical, marker-based, markerless, pattern, voice synthesized, etc.
- Focus on marker-based capture and how the tech works.
- Directory of market solutions (hw/sw), and relevant state-of-the-art literature on facial mocap.
- It's always a tricky dance with the Uncanny valley.
- Use DT's pipeline if needed to create demos and videos.
- Go through building a small facial mocap app using Processing.
  - Student creates a custom facial mocap system from scratch
  - Student captures his own performance and applies it to a simple cartoon character
  - Controls simple 2D character.
  - Do a live demo of this during class presentation.
- We're allowed to use short snippets of copyrighted video and marketing content, given proper attribution (e.g. "Property of Disney Interactive © 2014.") *AND* declaring that this project is for academic non-commercial use only.
  - Meaning: we can't post the course online and generate income from it (including income from Youtube ads).
  - We can still show it in class, post it online as a purely educational material, and use it as part of our cv/portfolio when applying for jobs.
- We need a whole section on applications of facial mocap; want to scour the internet for solid examples:
  - Film and gaming: this is the more obvious use-case and we don't have to emphasize it much
  - Medical: gotta find interesting use-cases here. This lines up well with the rest of the ELG5121 course material.
  - Social: similar to the tickling bodysuit that prof el saddik showed in class, virtual mocap might have social uses here.
  - Artificial Intelligence: analogous to speech recognition. Use facial mocap to read lips from surveillance videos? Judge the reaction of a large audience to a product?
  - Realtime vs. Offline uses.
- Mocap generally consists of several stages (a mocap pipeline, if you will):

Facial Rigging (real and virtual)	Performance Capture	Mapping and Retargeting	Animation Refinement

  - There is a clear separation between each stage, and they rarely overlap.
  - This separation is handy when assigning tasks to different members of the team (traditionally, each stage is handled by different person or group)
  - The whole process is highly technical, but it's interesting to note that as we move from left to right along this pipelines, things get slightly less technical and more creative/design-oriented.

c. Course Design

i. Conceptual: Videos

We deviated a bit from the description we initially set out in the Proposal, and instead decided to divide the content as follows

1. Greeting: this video was a necessary opener to grab the attention of any visitor to our site, and affirm the topic of the course up front. Very helpful to establish the mood of the course for the rest of the student's session. (get them inspired early on, their brilliant minds will take care of the rest). It also served as a quick outline of the website for those visiting for the first time.
2. Intro and Context: discusses a bit of historical context around facial mocap, and develops a sense of appreciation and understanding for current industrial and academic needs. Also highlights applications and use-cases *outside* of gaming or film, like Biomechanics research.

3. Mocap pipeline: illustrates the details of the entire process and explains the several consecutive steps needed. Applicable to both offline and real-time mocap systems.

Since we had many quick video cuts (changing camera rapidly between different shots), we attempted to incorporate a single background musical track to help tie the different pieces together, and to help us deliver a single educational narrative in an otherwise very busy video.

ii. Practical: Code

For the practical component of our course, we didn't want to teach the student how to use an existing facial mocap system, as we find the idea of clicking buttons and checking boxes to be trivial and lacking in any educational value, regardless of how impressive the final results would look like. So we agreed on developing the a simple but complete scaffolding application *from scratch* that delivers the full pipeline from an actor's face to a real-time 2D character. And we designed it so it wouldn't need any specialised equipment: the markers can be sticky notes or use washable marker pens directly on the face, and the camera can be any webcam available.

The final design ended up looking like this:

1. Matlab: for initial calibration of the face and continuous capturing after that. Matlab's image processing capabilities motivated us to us it, allowing advanced noise filtration and robustness given the low quality cameras we are targeting, along with poor lighting conditions (as opposed to a fully lit studio or pristine research desk environment). Once the markers were registered and accounted for, they were ported through TCP on a specific socket.
2. Data travels through TCP⋯.who's listening?
3. Processing is a Java-based graphics development environment designed for rapid iteration and code-generated graphical design. We programmed an little Processing app with a 2D character that has several built-in facial poses to choose from. The app is also listening to the same TCP port that the Matlab module is using. It collects this data as it comes, and immediately re-targets it to the matching facial pose (smile, sad, shock, etc.) in real-time.
4. With such a simple yet strong scaffolding, it's now very clear to the student where they could add their customizations for specialised functionality they're interested in pursuing (example, detect blinking).

A bonus side-effect that we were pleasantly surprised with was that we accidentally also showed how to develop a *remote* facial mocap solution, since technically, we can host the two modules on separate computers and use TCP as before. All in the same tutorial! We're quite satisfied with this as a good intro tutorial for any aspiring dev.

iii. Website Design

The decision to present all this programo-audio-visual information in a website was fairly easy, as no other platform can rival the support for so many medias in such an efficient and portable manner. Visually, we avoid clutter, and the website uses muted colors in comparison with the more vivid content of the course.

The site also gave us a chance to showcase a selected directory of top industry staples in the area of Facial Mocap systems, providing a launching pad for interested students.

3. Tools and Resources

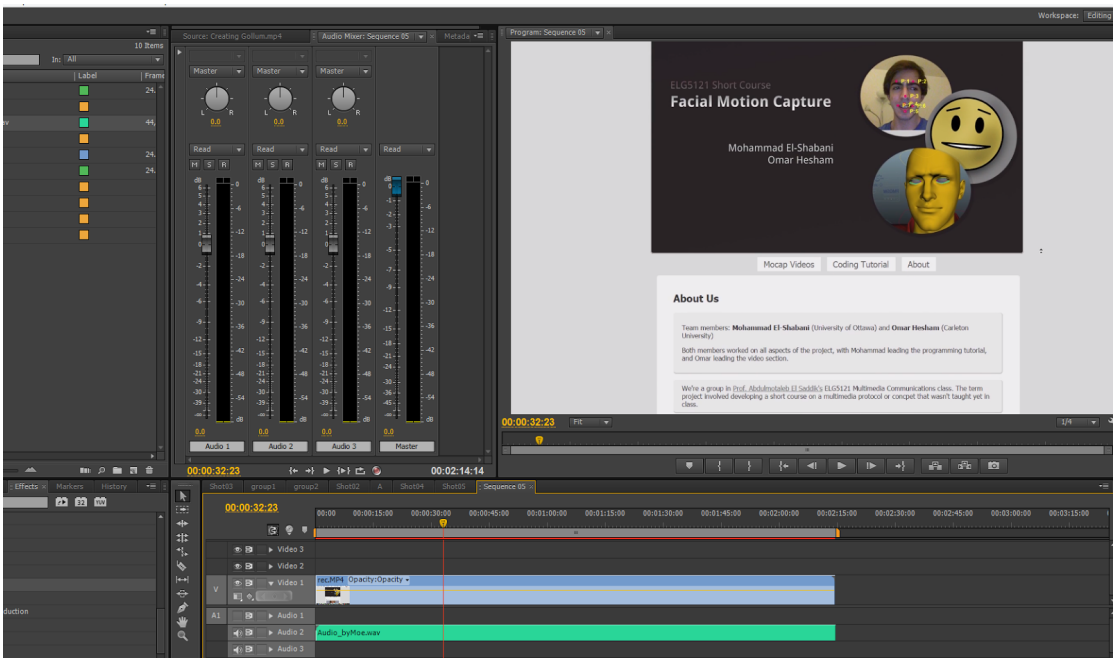
a. Video content

Unless otherwise indicated, all audiovisual content was produced by ourselves. We added an author tag to any content obtained externally. If there is no tag or existing watermark, then the content is ours. This further applies to source code.

We used *Photoshop* to produce the layouts, 2D shapes and text. We further used *Autodesk Maya* for 3D animation and rig demos. The facial mocap demoed in the first greeting video was produced using *Mixamo Face Plus*. Finally, we used *Open Broadcaster Software (OBS)* for screen recording whenever necessary.

b. Video editing

We used Adobe Premiere Pro to edit and produce the final video content (screenshot below).



c. Web development

We used Adobe Dreamweaver to script the website from scratch using HTML, and using CSS for styling. Because local files cannot load youtube frames, we hosted a mirror on our own server at www.omarhesham.com/elg5121

4. Workload Distribution & Scheduling

a. Task Assignment

We both had a hand in every aspect of the project, but overall Mohammad led the programming tutorial development, and I led the video content. The task journal discussed below further illustrates the balanced distribution of our tasks.

b. Scheduling

After a couple of initial meetings to discuss ideas around and plan out the month, we started keeping a journal of our milestones, which doubled as a task scheduling tool. We were able to comfortably update it as the term progressed. The next two pages show a snapshot from the beginning of the term, and one near the end. As with any project, we planned a few buffer days in case we ran into delays (and we did) which proved useful in the end.

i. Milestones Journal (beginning)

ELG5121 Project Milestones

Omar Hesham & Mohammad El-Shabani

Description - a quick timeline to help us organize things a bit, and a friendly reminder of what needs to be done and when.

#	Task	Details	Due Date	Primary		Status
				Omar	Moe	
1	Group Formation	Forming a group and submitting a project proposal.	Feb 1	x	x	Done
2	Group Meeting	Our first get-together and discussion of the project plan, deliverables and brainstorming ideas. (Repeats every Thursday at 6pm?)	Feb 5	x	x	WIP
3	Background Research	Compile a document, in bullet point form, of relevant sources (articles, video, products, etc.) on Facial Mocap. Also acts as a sketchpad for any personal thoughts, remarks, and ideas.	Feb 9	x	x	WIP
4	Mock Slides	Prepare ppt slides that roughly outline the content of the videos. We iron out the details of the videos in this form, before moving on to actual video and tutorial production.	Feb 14			N/A
5	Video Production	Produce final video tutorials according to mock slides.	Feb 20			N/A
6	Website	Design and develop a web page to present the content in.	Feb 22			
7	Mocap Directory	Compile a comprehensive listing of currently available commercial and academic tools (software/hardware) for facial mocap development (*the background doc we created earlier will make this step fairly easy*). Incorporate into website.	Feb 22			N/A
8	Project Presentation	A short presentation (10 slides in 10 minutes) showcasing our project. This is what we'd present in class at the end of term.	Feb 26			N/A
9	Project Demo	A 2 minute video to summarize our project. Sounds like a narrated screen capture of the final website, briefly outlining the educational content in it. If we run out of time, we could use the "Intro" video for this submission requirement.	Feb 26			N/A
10	Project Report	A comprehensive and concise technical report, comprised of: ☐ Formal design document and implementation details. ☐ Tools used, steps followed, and source code. ☐ Workload distribution and time management.	Feb 26	x	x	WIP
11	Final Submission	Submission of all project content on Blackboard	Feb 28			N/A
12	Buffer	Buffer day for any last minute edits / reuploads	Mar 1			N/A
13		*Add/remove task rows as needed throughout the term*				N/A
14	Bonus App *If time permits*	Homebrew marker-based mocap from scratch, using Processing. Try making it ourselves.	Feb 8	x		WIP
15		Convert it into a tutorial (video, article, or slides) to be included in the main website.	Feb 20			N/A

ii. Milestones Journal (end of February)

ELG5121 Project Milestones

Omar Hesham & Mohammad El-Shabani

Description - a quick timeline to help us organize things a bit, and a friendly reminder of what needs to be done and when.

#	Task	Details	Due Date	Primary		Status
				Omar	Moe	
1	Group Formation	Forming a group and submitting a project proposal.	Feb 1	x	x	Done
2	Group Meeting	Our first get-together and discussion of the project plan, deliverables and brainstorming ideas. (Repeats every Thursday at 6pm?)	Feb 5	x	x	Done
3	Background Research	Compile a document, in bullet point form, of relevant sources (articles, video, products, etc.) on Facial Mocap. Also acts as a sketchpad for any personal thoughts, remarks, and ideas.	Feb 9	x	x	Done
4	Mock Slides	Prepare ppt slides that roughly outline the content of the videos. We iron out the details of the videos in this form, before moving on to actual video and tutorial production.	Feb 16	x		Done
5	Video Production	Produce final video tutorials according to mock slides.	~~Feb 22~~ Mar 1	x		WIP
6	Website	Design and develop a web page to present the content in.	~~Feb 24~~ Mar 1	x		Done
7	Mocap Directory	Compile a comprehensive listing of currently available commercial and academic tools (software/hardware) for facial mocap development (*the background doc we created earlier will make this step fairly easy*). Incorporate into website.	~~Feb 24~~ Mar 1	x	x	Done
8	Project Presentation	A short presentation (10 slides in 10 minutes) showcasing our project. This is what we'd present in class at the end of term.	Feb 26	x		N/A
9	Project Demo	A 2 minute video to summarize our project. Sounds like a narrated screen capture of the final website. If we run out of time, we could use the "Intro" video for this submission.	~~Feb 26~~ Feb 28		x	Done
10	Project Report	A comprehensive and concise technical report, comprised of: ☐ Formal design document and implementation details. ☐ Tools used, steps followed, and source code. ☐ Workload distribution and time management.	~~Feb 26~~ Mar 2	x	x	WIP
11	Final Submission	Submission of all project content on Blackboard	Feb 28	x	x	N/A
12	Buffer	Buffer day for any last minute edits / reuploads	Mar 1			N/A
13		*Add/remove task rows as needed throughout the term*				
14	~~Bonus~~ Demo App ~~*if time permits*~~	Homebrew marker-based mocap from scratch, using Processing. Try making it ourselves.	Feb 8		x	Done
15		Convert it into a tutorial (video, article, or slides) to be included in the main website.	Feb 20		x	Done
16		Documentation and source code	Feb 26		x	Done

c. Data management

We maintained shared access to a Google Drive throughout the duration of the project, which kept our files organized and backed up in case of needed revisions, or in emergencies.

5. Source code samples (from 'mocap_tutorial.zip')

a. Matlab

```
noseToUpperLiprt=distance(stats(ordering(3)).Centroid, stats(ordering(4)).Centroid);
noseToREBnrt= distance(stats(ordering(3)).Centroid, stats(ordering(2)).Centroid)/ noseToUpperLiprt;
noseToLEBnrt=distance(stats(ordering(3)).Centroid, stats(ordering(1)).Centroid)/ noseToUpperLiprt;
mouthOpenningnrt=distance(stats(ordering(4)).Centroid, stats(ordering(5)).Centroid)/ noseToUpperLiprt;
mouthOpenningvnrt=distance(stats(ordering(6)).Centroid, stats(ordering(7)).Centroid)/ noseToUpperLiprt;

noseToREBnrtC = noseToREBnrt/noseToREBn;
noseToLEBnrtC = noseToLEBnrt/noseToLEBn;
mouthOpenningnrtC = mouthOpenningnrt/mouthOpenningn;
mouthOpenningvnrtC = mouthOpenningvnrt/mouthOpenningvn;

brows = ( noseToREBnrtC + noseToLEBnrtC)/2;
brows = brows -1;
mouthOpen = mouthOpenningnrtC-1;
mouthOpenV=mouthOpenningvnrtC-1

smile = 0; surprise=0;frown=0;sad=0;
if ( mouthOpen  - 0.05 >0)
    if (mouthOpenV >0)
        smile = 2*mouthOpenV
        fwrite(t,'s');
        fwrite(t,smile*255);


    else
        surprise = 2*mouthOpen
        fwrite(t,'r');
        fwrite(t,surprise*255);

    end
```

b. Processing (drawing smooth curves)

```
 bezier(150+(float) (0.50* (surprise *(MAX_SUR))) + (float)( 0.50* (frown *(MAX_FROWN))), 295,
        200, lowerlipCurveP1,
        300, lowerlipCurveP2,
        350-(float)( 0.50* (surprise *(MAX_SUR)))  - (float)( 0.50* (frown *(MAX_FROWN))), 295);
fill (255);
   bezier(150+(float)( 0.50* (surprise *(MAX_SUR))) + (float)( 0.50* (frown *(MAX_FROWN))), 295,
        200,   295 - (float) (0.5* (surprise *(MAX_SUR))) -(float) (0.1 *(sad *(MAX_SAD))),
        300,   295 - (float) (0.5 *(surprise *(MAX_SUR))) - (float) (0.1 *(sad *(MAX_SAD))),
        350-(float)( 0.50* (surprise *(MAX_SUR))) - (float)( 0.50* (frown *(MAX_FROWN))),   295);
```

c. Marker Placement (from 'faceplacement' file)

6. Conclusion

a. Goals Achieved

We have learned quite a bit from this experience, and enjoyed getting to meet and work with a new classmate. The project allowed us to explore a fun topic in a very productive way. Overall, we feel we've completed the project goals we initially set out to produce. Using 3 medias, if you count Mohammad's marker-filled face :)

b. Given more time…

We would have liked to add *Closed Captioning* for accessibility to our videos. We would have also enhanced our mocap demo to include eye blinking markers and face-orientation tracking. Additionally, we would have liked more time to improve the graphics and animation quality, especially in the Pipeline video, which ended up being a bit too static due to time constraints.

Thanks for reading so far! Till next time, have a lovely day. Peace.