Department of Computer Science & Engineering
The University of Texas at Arlington

Project Charter
CSE 4316: Senior Design I
Summer 2024

MosaicMovements
In/e Motion

Derrick Perry
Sophia Dao
Asad Mirza
John Calma

Revision History

Revision	Date	Author(s)	Description
0.1	06.20.2024	DP	document creation
0.2	06.26.2024	DP, SD, AN, JC	complete draft
0.3	06.27.2024	JC	revised draft

Contents

1 Problem Statement **6**

2 Methodology **6**

3 Value Proposition **6**

4 Development Milestones **6**

5 Background **7**

6 Related Work **7**

7 System Overview **8**

8 Roles & Responsibilities **10**

9 Cost Proposal **11**
9.1 Preliminary Budget . . . 11
9.2 Current & Pending Support . . . 11

10 Facilities & Equipment **11**

11 Assumptions **12**

12 Constraints **13**

13 Risks **14**

14 Documentation & Reporting **15**
14.1 Major Documentation Deliverables . . . 15
14.1.1 Project Charter . . . 15
14.1.2 System Requirements Specification . . . 15
14.1.3 Architectural Design Specification . . . 15
14.1.4 Detailed Design Specification . . . 15
14.2 Recurring Sprint Items . . . 15
14.2.1 Product Backlog . . . 15
14.2.2 Sprint Planning . . . 15
14.2.3 Sprint Goal . . . 15
14.2.4 Sprint Backlog . . . 16
14.2.5 Task Breakdown . . . 16
14.2.6 Sprint Burn Down Charts . . . 16
14.2.7 Sprint Retrospective . . . 16
14.2.8 Individual Status Reports . . . 16
14.2.9 Engineering Notebooks . . . 16
14.3 Closeout Materials . . . 16
14.3.1 System Prototype . . . 16
14.3.2 Project Poster . . . 16
14.3.3 Web Page . . . 17

14.3.4 Demo Video 17
14.3.5 Source Code 17
14.3.6 Source Code Documentation 17
14.3.7 Hardware Schematics 17
14.3.8 Installation Scripts 17
14.3.9 User Manual 17

List of Figures

1 Early system mockup design 10
2 Sprint 1 burn down chart 16

1 Problem Statement

The In/E Motion project was started in the spring of 2024 as a way for the arts and computer science to collaborate. The MosaicMovements project aims to revolutionize performance spaces by integrating motion tracking and AI to create interactive environments that respond to the actions of performers and the audience. This project seeks to transform traditional performance art into a dynamic, immersive experience where the environment and participants are in constant, real-time dialogue. By doing so, MosaicMovements will not only enhance artistic expression and engagement but also pave the way for innovative and groundbreaking performances that redefine the boundaries of interactive art.

2 Methodology

The objective of the In/E Motion project is to bring the world of computer science and art together. To achieve this, MosaicMovement will design a system that consists of multiple cameras capturing movements made by performers and using advanced AI algorithms to generate an immersive space. The immersive space will be projected throughout the room and change depending on how the AI interprets the performers' movements.

3 Value Proposition

Investing in the MosaicMovements project offers sponsors a unique opportunity to support a transformative initiative that combines technological innovation with artistic expression. The project not only promises significant advancements in interactive performance spaces but also provides educational benefits, commercial opportunities, and cultural impact. By backing this project, sponsors will be contributing to a pioneering effort that has the potential to revolutionize how we experience and engage with performances, setting new standards in the industry.

4 Development Milestones

This list of core project milestones should include all major documents, a demonstration of major project features, and associated deadlines. Any date that has not yet been officially scheduled at the time of preparing this document may be listed by month. Some of the milestones below are labeled as to be determined for future updates to the project charter.

- Project Charter first draft - June 2024
- System Requirements Specification - July 2024
- Architectural Design Specification - July 2024
- Demonstration of Motion Tracking - July 2024
- Detailed Design Specification - September 2024
- Demonstration of AI implementation - TBD
- Demonstration of Image Projection - TBD
- Demonstration of User Interface - TBD
- Final Project Demonstration - December 2024

5 BACKGROUND

The Fine Arts Department at the University of Texas at Arlington is dedicated to advancing the arts through innovation and technology. In traditional performance spaces, the interaction between performers, the audience, and the environment is often limited to passive observation. This lack of interactivity can result in a disengaging experience for the audience and restrict the creative expression of performers. The advent of advanced motion tracking and artificial intelligence (AI) technologies presents a significant opportunity to transform performance spaces. By integrating these technologies, we can create an interactive environment that responds dynamically to the movements of both performers and the audience. This project aims to address the current limitations and unlock new dimensions of artistic expression and audience engagement. MosaicMovement, consisting of senior design students from the computer science departments, has been selected to work on this project due to their expertise in technology and innovation. The collaboration with the Fine Arts Department is a continuation of an existing relationship aimed at integrating technology with artistic endeavors. The previous team laid the groundwork by exploring the feasibility of using motion tracking and AI in performance spaces. Our team will build upon this foundation, bringing the project closer to realization. The MosaicMovements project is a strategic initiative that addresses the limitations of traditional performance spaces by leveraging advanced motion tracking and AI technologies. This project aligns with the Fine Arts Department's mission to innovate and enhance the educational, cultural, and community impact of the arts. By creating an interactive and immersive environment, we aim to revolutionize how performances are experienced and elevate the standards of artistic expression and audience engagement.

6 RELATED WORK

To develop an innovative interactive performance space using motion tracking and AI, it is essential to understand the current state-of-the-art in similar projects. Various solutions exist across academic research, enthusiast prototypes, and commercially available technologies. Here we will explore these solutions, evaluate their strengths and limitations, and justify why they are not fully suitable for our sponsors.

1. **HeavyM Interactive Art Installation:** HeavyM is a software solution that allows users to create interactive art installations using sensors [2]. The software enables real-time interaction with visuals based on sensor input, making it popular for art installations and performances.

- Limitations: While HeavyM provides robust tools for visual interaction, it is primarily designed for simpler, less dynamic installations. It lacks advanced motion tracking capabilities and real-time adaptability required for complex dance performances.

2. **TouchDesigner's Real-Time Body Tracking and Projection Mapping:** The TouchDesigner group has created real-time body tracking and projection mapping setups [4]. These projects use motion tracking to map visuals onto moving bodies, creating an interactive experience.

- Limitations: These projects often rely on consumer-grade equipment and DIY solutions, which may not offer the precision, reliability, and scalability needed for professional performance spaces. Additionally, they may require significant customization and technical expertise to implement effectively.

3. **Memo Aktens Body Paint:** "Body Paint" by Memo Akten is an interactive installation that uses body tracking to create digital paintings with movement [1]. The installation captures the movements of participants and translates them into visual art.

- Limitations: Although innovative, Body Paint focuses on individual interactions and artistic expression rather than creating an immersive, interactive environment for both performers and audiences. It does not provide the comprehensive, real-time feedback and adaptability necessary for complex performance spaces.

4. **Hypebeast Video Mapping Dance Performances:** Video mapping on dance performances is showcased by various artists and companies, including a notable example highlighted on Hypebeast [3]. This technology maps visuals onto dancers, enhancing the performance with dynamic visual effects.

- Limitations: While video mapping adds a visual layer to performances, it typically does not involve real-time interaction based on motion tracking. The technology enhances the visual aspect but lacks the interactivity and responsiveness that our project aims to achieve.

5. **Wake: An Interactive Projection Mapping Dance Performance:** "Wake" is an interactive dance performance that uses projection mapping to create an immersive experience [5]. The project integrates body tracking and projection mapping to enhance the visual narrative of the performance.

- Limitations: Although Wake combines body tracking with projection mapping, it is primarily an artistic project rather than a robust, scalable solution for various performance spaces. It may not offer the flexibility, ease of use, and integration capabilities required for our project's goals.

The existing solutions provide valuable insights and demonstrate the potential of integrating motion tracking and visual interaction in performance spaces. However, they fall short in several key areas:

- Precision and Reliability: Many solutions rely on consumer-grade equipment or DIY setups, which may not provide the precision and reliability needed for professional performances.
- Scalability: Current technologies may not scale well to larger performance spaces or support multiple performers and audience interactions simultaneously.
- Real-Time Adaptability: Few existing solutions offer the real-time adaptability required to create a fully immersive and interactive environment that responds dynamically to both performers and the audience.
- Comprehensive Integration: Our project aims to integrate motion tracking and AI comprehensively, ensuring seamless interaction between performers, the audience, and the environment.

7 System Overview

The MosaicMovements project aims to create an interactive performance space that leverages advanced motion tracking and artificial intelligence to enhance engagement and dynamism between performers, the audience, and the environment. Below is a high-level overview of the system components and their interactions:

1. **Motion Tracking Subsystem:**
    - Sensors and Cameras: Multiple high-resolution cameras and sensors will be strategically placed around the performance space to capture the movements of performers and the audience. These devices will provide comprehensive coverage, ensuring that all movements are accurately recorded.

- Data Processing Unit: The raw data from the sensors and cameras will be sent to a centralized data processing unit, where it will be analyzed in real-time to detect and interpret body movements.

2. **AI Interaction Engine:**

   - Motion Analysis Module: This module will utilize AI algorithms to analyze the processed motion data, identifying specific movements and gestures. The AI will be trained to recognize various actions and determine the appropriate responses.
   - Response Generation Module: Based on the analysis, this module will generate dynamic responses, including visual, auditory, and environmental effects. The AI will ensure that these responses are contextually relevant and enhance the overall performance experience.

3. **Interactive Environment Subsystem:**

   - Visual Display Units: Projectors and LED screens will be used to display dynamic visual effects that change in response to the detected movements. These visual elements will be synchronized with the performers' actions, creating a seamless interactive experience.
   - Audio System: An advanced audio system will provide real-time sound effects and music that respond to both the performers' and the audience's movements. This subsystem will ensure that the auditory experience is immersive and complements the visual effects.
   - Environmental Controls: Additional environmental elements, such as lighting and fog machines, will be integrated into the system to further enhance the interactive experience. These controls will be dynamically adjusted based on the AI's analysis of the performance space.

4. **User Interface and Control Panel:**

   - Performance Dashboard: A user-friendly dashboard will allow performers and technical directors to control and adjust various aspects of the interactive environment. This interface will provide real-time feedback and allow for customization of the interaction settings.
   - Remote Access: The control panel will support remote access, enabling adjustments to be made from various devices, such as tablets or smartphones. This flexibility will ensure that the system can be managed efficiently during live performances.

1. Motion Capture: The sensors and cameras continuously capture the movements within the performance space. Data is streamed in real time to the data processing unit.

2. Data Processing: The processing unit analyzes the raw data to detect and interpret movements. Key points and movement patterns are identified and sent to the AI interaction engine.

3. AI Analysis and Response: The motion analysis module interprets the movements and determines appropriate responses. The response generation module creates dynamic visual, auditory, and environmental effects based on the analysis.

4. Interactive Environment Adjustment: Visual displays, audio systems, and environmental controls are dynamically adjusted in real time. The performance dashboard allows for monitoring and manual adjustments as needed.

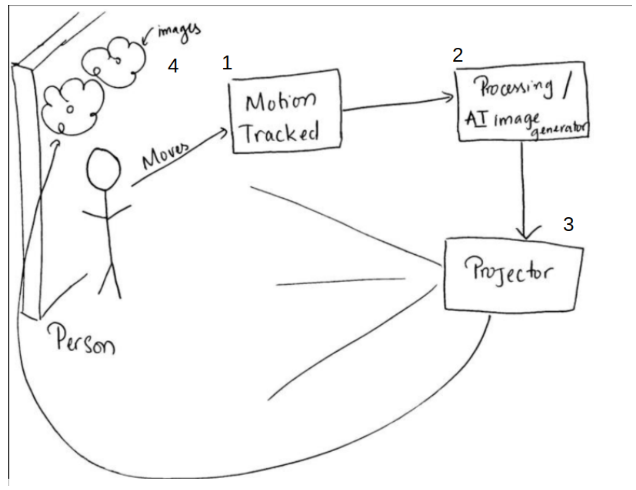

Figure 1: Early system mockup design

8 Roles & Responsibilities

The primary stakeholders for the MosaicMovements project include the Fine Arts Department at the University of Texas at Arlington (UTA), represented by our sponsors, as well as the team members working on the project. The key stakeholders are:

Sponsor Representatives:

- Laurie Taylor, Area Head Dance Minor at UTA
  Role: Provides expertise and guidance on the artistic and performance aspects of the project.
  Responsibility: Ensures that the project aligns with the needs and expectations of the Dance Minor program, facilitating communication between the team and the dance faculty.
- Leah Mazur, BFA Design Tech Area Head at UTA
  Role: Provides expertise and guidance on the design and technical aspects of the project.
  Responsibility: Ensures that the project aligns with the technical and design standards of the BFA Design Tech program, facilitating communication between the team and the design faculty.

MosaicMovements Team Members:

- Derrick Perry, Computer Software Engineering Student at UTA
  Role: Team Leader
  Responsibility: Oversees the overall progress of the project, ensures milestones are met, manages the project timeline, and acts as the primary liaison between the team and sponsors.
- Sophia Dao, Computer Science Student at UTA
  Role: Specialist
  Responsibility: Focuses on the implementation and optimization of the motion tracking subsystem, ensuring accurate and reliable capture of movements.
- John Calma, Computer Science Student at UTA
  Role: Developer
  Responsibility: Leads the development of the software components, including motion tracking integration, AI interaction engine, and system interface.

- Asad Mirza, Computer Science Student at UTA
  Role: Tester
  Responsibility: Integrates all system components and conducts thorough testing to ensure the system functions seamlessly and meets performance requirements.

9 Cost Proposal

The MosaicMovements team will use the funding provided by the university's Fine Arts Department and the allocated budget provided by the Computer Science Department to advance the In/E Motion project. While some equipment has already been purchased by the university for this project, the team may need additional funding for the project to scale up the current system.

9.1 Preliminary Budget

Item	**Use**	**Estimated Cost**
Camera	Motion Tracking	$300
Software APIs	AI Implementation	$200
Total Estimated Cost		**$500**

Table 1: Identified equipment and estimated budget

9.2 Current & Pending Support

Source	**Amount**	**Status**
UTA CSE Department	$800	Available
National Endowment for the ARTS	$10,000-$100,000	Pending
Grants for Performing Arts in Texas	$5,000-$15,000	Pending

Table 2: Prospect grants to fund in/e motion

10 Facilities & Equipment

To successfully complete the In/E Motion project, the MosaicMovements team will utilize several key facilities and equipment. These resources are essential for the development, testing, and integration of the interactive performance space system.

1. Workstation: The team will have access to a designated workstation in the Senior Design Lab. This space will serve as the primary development and testing area.

2. Personal Projector: The workstation is equipped with a personal projector, which will be crucial for testing and demonstrating the visual components of the interactive environment.

3. Linux PC: A PC is available at the workstation, preloaded with OpenPose, the motion-tracking software essential for detecting and analyzing body movements.

4. Performance Space: Room 143 in the Fine Arts Building will serve as the performance space for real-world testing and demonstration of the interactive environment. This space is equipped with the necessary infrastructure.

5. Sensors and Cameras: High-resolution cameras and sensors will be required to capture the movements of performers and the audience. These will be sourced through a combination of borrowing from the university and purchasing new equipment within the budget constraints.

6. Projectors and Screens: Additional projectors and screens may be needed for creating an immersive visual environment.

7. Software Licenses: Any additional software licenses required for development (e.g., for AI tools, and development environments) will be acquired through the universityâs software licensing agreements.

11 Assumptions

The following list contains critical assumptions related to implementing and testing the MosaicMovements project. These assumptions are based on our current knowledge, experience, and the information available at this stage. They are anticipated events or circumstances that we expect to occur during the project's life cycle. However, should any of these assumptions be proven false, they could significantly impact the project's progress and success.

1. Availability of Performance Space:
   - Assumption: A suitable indoor performance space equipped with necessary infrastructure (power, network connectivity, and space for sensor and camera setup) will be available for testing and implementation by the 3rd sprint cycle.
   - Impact if False: Delays in testing and implementation phases; potential need to find alternative spaces, which could incur additional costs and logistical challenges.

2. Timely Delivery of Equipment:
   - Assumption: All required sensors, cameras, and hardware components for the motion tracking subsystem will be delivered according to specifications by the 2nd sprint cycle.
   - Impact if False: Potential delays in setting up the motion tracking system, leading to a cascading effect on subsequent development and testing phases.

3. Access to Sponsor and Previous Team:
   - Assumption: The project team will have regular access to the sponsors, Laurie Taylor and Leah Mazur, and members of the previous project team for guidance, knowledge transfer, and feedback throughout the project.
   - Impact if False: Gaps in understanding the project's current state, potential misalignment with sponsor expectations, and challenges in maintaining continuity with the previous team's work.

4. Stable Network and Power Infrastructure:
   - Assumption: The performance space will have a stable and robust network and power infrastructure capable of supporting the continuous operation of sensors, cameras, and computing equipment.
   - Impact if False: Interruptions in system operation during testing and performances, leading to unreliable results and potential damage to equipment.

5. AI and Motion Tracking Software Compatibility:
    - Assumption: The selected AI and motion tracking software (e.g., OpenPose) will be compatible with the hardware setup and will perform as expected in real time without significant latency or accuracy issues.
    - Impact if False: Technical difficulties in integrating software with hardware; potential need for alternative solutions, which could result in additional development time and costs.
6. Audience and Performer Participation:
    - Assumption: Performers and audience members will be willing and available to participate in testing and demonstrations of the interactive performance space throughout the project's duration.
    - Impact if False: Limited opportunities for real-world testing and feedback, which could affect the refinement and validation of the system.
7. Funding and Resources:
    - Assumption: The project will have adequate funding and resources allocated throughout its duration to cover all necessary expenses, including equipment, software licenses, and unexpected costs.
    - Impact if False: Financial constraints could limit the scope and quality of the project, leading to compromises in the system's capabilities and performance.

12 Constraints

Below are constraints for the MosaicMovements team while working on the In/E Motion Project:

1. **Final Prototype Demonstration Deadline:** The final prototype demonstration must be completed by December 8th, 2024.
   Impact: The project timeline must be strictly managed to ensure all development, testing, and iterations are completed by this date.
2. **Access to Customer Installation Site:** The customer installation site will only be accessible by the development team during normal business hours (9 AM to 5 PM, Monday to Friday).
   Impact: All on-site work, including setup, testing, and troubleshooting, must be scheduled within these hours, potentially limiting the time available for addressing issues.
3. **Budget Limitation:** Total development costs for the team must not exceed 800 dollars for their department.
   Impact: The team must carefully manage expenses, prioritize essential components and services, and seek cost-effective solutions to stay within the budget.
4. **Hardware and Software Availability:** The availability of specific hardware components and software licenses may be limited due to supply chain issues or licensing restrictions.
   Impact: The project schedule must account for potential delays in acquiring necessary components and software, and contingency plans must be in place to address any shortages or licensing issues.

5. **Compliance with Safety Regulations:** The project must comply with all relevant safety regulations and standards, including electrical, fire, and occupational safety codes.
   Impact: The design and implementation of the system must incorporate safety considerations, and additional time and resources may be needed to ensure compliance and obtain necessary certifications.

By identifying and documenting these critical constraints, the MosaicMovements team can proactively manage the project within the defined boundaries and develop strategies to mitigate any potential impacts on progress and success.

13 RISKS

Risk	Probability of Occurence	Loss (Days)	Risk Exposure (Days)
1. Delay in Equipment Delivery	30%	10	3
2. Limited Access to Performance Space	30%	10	3
3. Challenges with AI Integration	50%	14	7
4. Insufficient Participant Availability	20%	8	1.6
5. Deviation from Project Goal	30%	10	3

Table 3: Overview of highest exposure project risks

1. Delay in Equipment Delivery:

   Probability of Occurrence: 0.3
   Size of Loss: 10 days
   Risk Exposure: 3 days
   Description: The delivery of essential sensors and cameras may be delayed, affecting the setup and testing phases.

2. Limited Access to Performance Space:

   Probability of Occurrence: 0.3
   Size of Loss: 10 days
   Risk Exposure: 3 days
   Description: Room 143 in the Fine Arts Building might not be available as planned, causing delays in real-world testing.

3. Challenges with AI Integration:

   Probability of Occurrence: 0.5
   Size of Loss: 14 days
   Risk Exposure: 7 days
   Description: Integrating AI with the motion tracking system might cause unforeseen technical issues, requiring additional time for resolution.

4. Insufficient Participant Availability:

   Probability of Occurrence: 0.2
   Size of Loss: 8 days
   Risk Exposure: 1.6 days

Description: Performers and audience members may not be available as needed for testing, delaying feedback and system refinement.

5. Deviation from Project Goal:

   Probability of Occurrence: 0.3
   Size of Loss: 10 days
   Risk Exposure: 3 days
   Description: The project scope is broad and can result in different ideas that conflict, causing system design issues.

14 Documentation & Reporting

14.1 Major Documentation Deliverables

14.1.1 Project Charter

The MosaicMovements team leader will maintain the project charter. Updates will be made throughout each sprint. The initial version of the charter will be delivered in June 2024 and the final version will be submitted before the final sprint of Senior Design 2.

14.1.2 System Requirements Specification

The MosaicMovements team leader and specialist will maintain the project charter. Updates will be made throughout each sprint. The initial version of the charter will be delivered in July 2024 and the final version will be submitted before the final sprint of Senior Design 2.

14.1.3 Architectural Design Specification

The MosaicMovements team leader and specialist will maintain the project charter. Updates will be made throughout each sprint. The initial version of the charter will be delivered in July 2024 and the final version will be submitted before the final sprint of Senior Design 2.

14.1.4 Detailed Design Specification

The MosaicMovements team leader and specialist will maintain the project charter. Updates will be made throughout each sprint. The initial version of the charter will be delivered September 2024 and the final version will be submitted before the final sprint of Senior Design 2.

14.2 Recurring Sprint Items

14.2.1 Product Backlog

The MosaicMovements team will use Trello to create boards for each sprint. These boards will be accessible to the sponsors and product owners. The boards will contain lists and sprint burndown chart information that will be cataloged throughout each sprint. The team will test and vote together on what software will be implemented in the project.

14.2.2 Sprint Planning

The MosaicMovements team will plan out each sprint using the Trello application. This will allow each member to assign themselves to specific tasks as well as provide a burndown chart that can be referenced. The team will begin each sprint by reviewing what documentation needs to be completed and prioritizing development based on importance to the sponsor.

14.2.3 Sprint Goal

The MosaicMovements team will establish sprint goals during the sprint review period with the sponsors. As a team, we will discuss and analyze progress to determine the next steps for development.

14.2.4 Sprint Backlog

The MosaicMovements team will agree on the items in the sprint backlog. The team leader will create the log and present it to their team members for everyone to confirm. The backlog will be located in Trello.

14.2.5 Task Breakdown

The MosaicMovements team members will discuss tasks and base the responsibility of said task on who wants to complete it. Tasks that do not get claimed will be handled or given out by the team leader.

14.2.6 Sprint Burn Down Charts

The MosaicMovements team member who is designated as the specialist will be responsible for generating the sprint burn-down charts for each sprint.

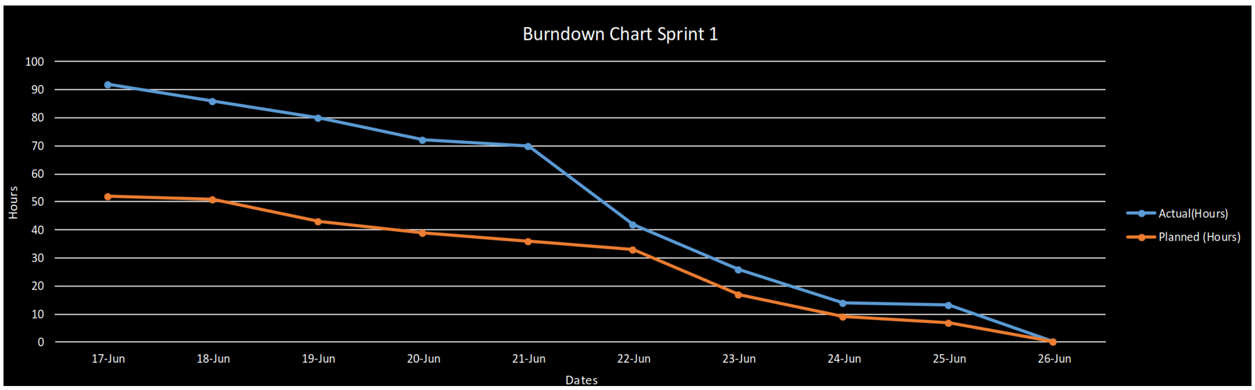

Figure 2: Sprint 1 burn down chart

14.2.7 Sprint Retrospective

The MosaicMovements team will have sprint review meetings discussing how tasks were handled and progress was made after each sprint. This meeting will engage the team so they can improve any mistakes or misunderstandings that were encountered during the previous sprint.

14.2.8 Individual Status Reports

Each MosaicMovements team member will fill out an Individual Status Report that details their personal experience for each sprint. The report will go into detail on what said member contributed in that sprint. This report will be delivered at the end of each sprint after the sprint review meeting.

14.2.9 Engineering Notebooks

Engineering notebooks will not be used.

14.3 Closeout Materials

14.3.1 System Prototype

The final system prototype will be a Field Acceptance Test that must be approved by the sponsors.

14.3.2 Project Poster

The project poster will contain an overview of the contributions that the MosaicMovements team made to the In/E Motion project. New key features and improvements to the current system design will be detailed on the poster. A standard A0 size poster will be used and the poster will be delivered before the final demo of the project.

14.3.3 Web Page

Improvements to the existing web page for the In/E Motion project will be made. Updates that the MosaicMovements team contributed to the project will be noted.

14.3.4 Demo Video

The demo video will show how the system works. The video will include dancers and/or participants moving and how the interactive space reacts to said movement.

14.3.5 Source Code

The source code will be in a GitHub repository that will be accessible to the sponsors. If the sponsors choose for the project to be open source then that is up to them, not the MosaicMovements team. The standard licenses and overview of the system will be available in a readme file located in the repository.

14.3.6 Source Code Documentation

The MosaicMovements team will keep a detailed PDF document on how the system works and how the components interact with one another. The sponsors for this project are Fine Arts professors so keeping a document that is easily discernible to a non-programmer is important.

14.3.7 Hardware Schematics

Projectors and cameras will be used for this project.

14.3.8 Installation Scripts

This project is an art installation piece that will be given to the University of Texas at Arlington's Fine Arts department. Our goal for this project is to create a space that meets their needs only.

14.3.9 User Manual

A manual to set up the environment for the system to be used will be provided to the sponsor upon request. The project space is provided by the department so they will already have a dedicated setup.

References

[1] Memo Akten. Body paint, 2024.

[2] HeavyM. Interactive art installation with sensors, 2024.

[3] Hypebeast. Video mapping dance performance, 2015.

[4] TouchDesigner Forum. Real-time body tracking and projection mapping, 2024.

[5] TouchDesigner Forum. Wake: An interactive projection mapping dance performance, 2024.