

XR Open Source Fellowship Program

BUILDING DIGITAL PUBLIC GOODS FOR THE METAVERSE

XROS Fellowship <> NIFT - Final Project Report

Basic Information

No.	Details	Response
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3	Project Name / Organisation Name	NIFT-Delhi
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6	Project Title	SMOTS - Seam Sealing Machine Operation Training Simulator
7	Project GitHub Link	https://github.com/XROS-X-NIFT/SMOTS
8	Video Link	 SMOTS Seam-sealing Operator Trai...
9	Number of Hours you worked on during the XROS Fellowship Journey	250 at least.
10	Were the weekly/fortnightly meetings attended by you (Yes / No)	Yes

Table Of Contents

Background.....	3
About the Project.....	4
Details.....	4
Machine.....	4
Function.....	5
Simulation.....	8
Technology Stack:.....	12
Hardware.....	12
Software.....	13
Goals.....	17
Contribution.....	18
1. Mesh.....	18
2. Armature.....	19
3. Material.....	19
4. Lighting.....	20
5. Pipeline.....	21
6. UI.....	21
7. Project file management.....	21
Management.....	21
Suggestions.....	22
Mentors.....	22
Special Mention.....	23
Regards.....	23

Background

I am Aniket Rana a 4th year student of B.Tech in Electronics and Communication at NIT-Surat. I am very passionate about 3D graphics design and Metaverse. It's rare to find opportunities in this domain as it's currently evolving. When I got to know about the XROS Fellowship I knew it was an excellent opportunity to explore this domain in depth by working on an actual project, So I went through the details and joined the Slack community. Where I met amazing people. I discussed some projects with their mentors. I joined the Q&A sessions of the organizations that were hosted on YouTube. In the end, I decided to write proposals for 3 projects,

- NIFT - SMOTS
- House of Kriffin - Krifin
- The Hacedor - TheHacedor

The SMOTS was my 1st priority because it was a practical problem. So I did some research about the machine and as per their requirement, I drafted the proposal as detailed as possible.

I got qualified for the second round where we were given a task to share the workflow of the project according to our understanding. And then in the end I had an interview with the mentors of the project (Professors of NIFT-Delhi), which went nicely.

And the day came when I received the acceptance letter from Punit Jain on 6th April. I was delighted by this news. Within 1-2 days I was invited to the WhatsApp group of the project and we had a onboarding meeting where we got to know more about our fellow team members and mentors after we started discussing the project.

About the Project

Details

SMOTS - Seam Sealing Machine Operation Training Simulator

This HoloLens2 application provides the user with an immersive experience of training on a Seam-Sealing machine. Using this he can learn to operate the machine in virtual simulation and when he will be using the actual machine he will be aware of its working.

Here users can get an experience of using the machine virtually anywhere any time. He requires to wear a Hololens headset and he can interact with the virtual objects in a real environment using just his hands and legs.

Machine



Displayed model code: AI-001 spec A-NNN

We used the **AI-001 Hot Air Seam Sealing Machine by the H&H model** for our simulation. There were multiple reasons for using this particular model.

- It's very basic and beginner friendly.

- Our mentors were aware of its operation as well as they had their contacts with the manufacturer which leads to arranging an offline meet-up at the factory.
- The basic CAD mesh was already provided.

Function

- As the user starts the application a splash screen appears.



- At the beginning, the user is greeted with a welcome.

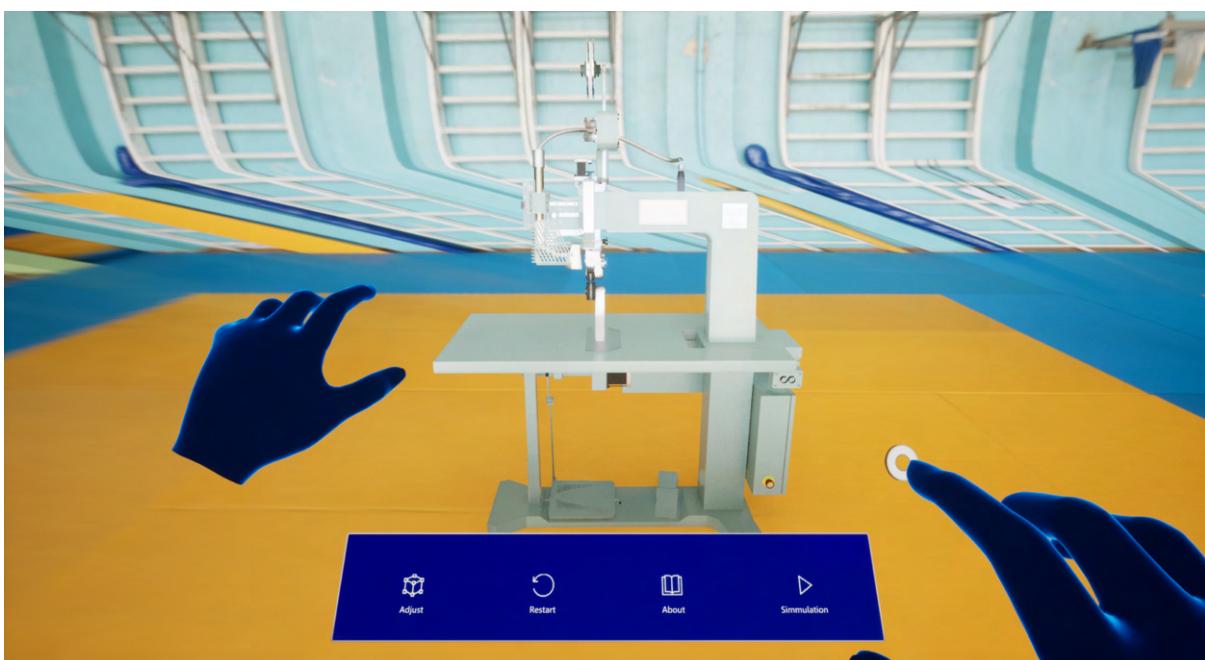


- Then he can go through the parts details of the machine.



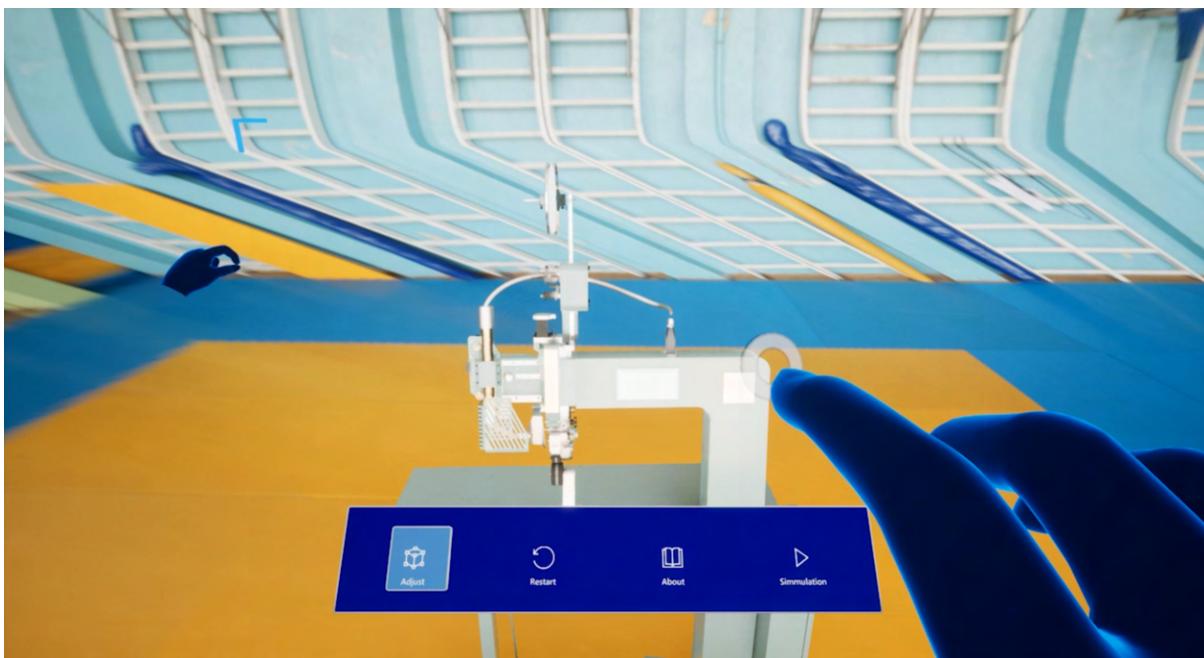
Here he/she can move around and see the details of the parts.

- Now comes the main menu,



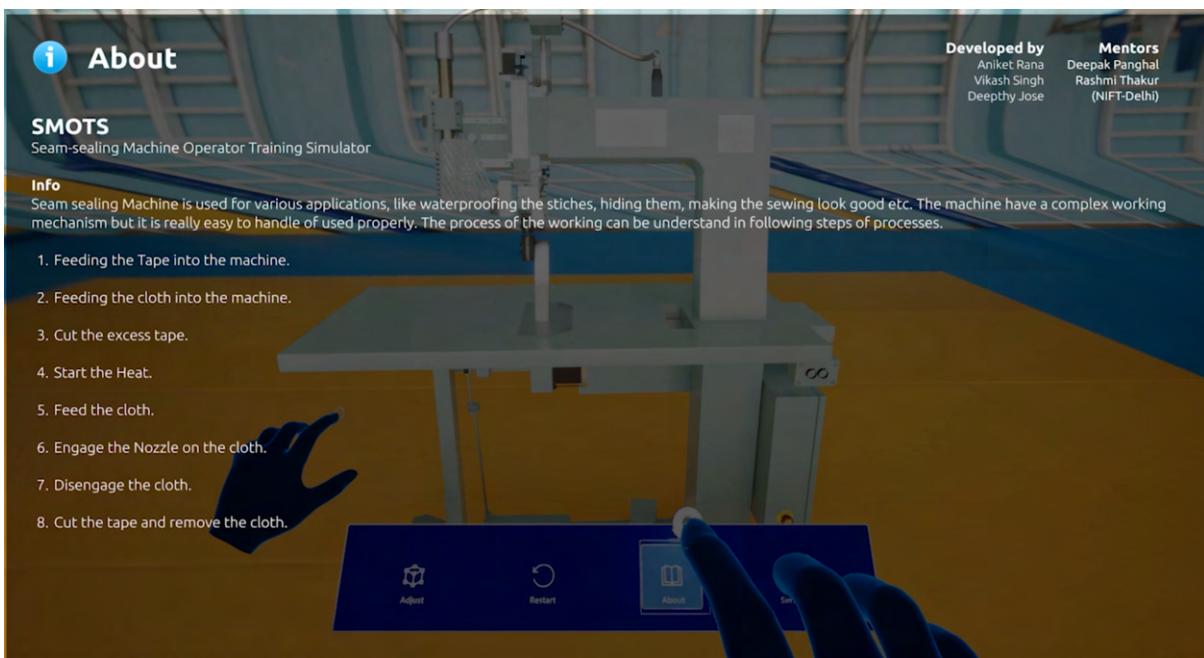
As shown above, It has 4 options in front of the user,

1. **Adjust:** Adjust the machine placement in the viewport.



2. **Restart:** To restart the entire application.

3. **About:** The details of the project.



4. **Simulation:** to start the simulation.

Simulation

The UI is made as simple as possible so the user does not mess up anything.

1. Precautions



There are some essential precautions are there to be taken while operating the actual machine which is provided here.

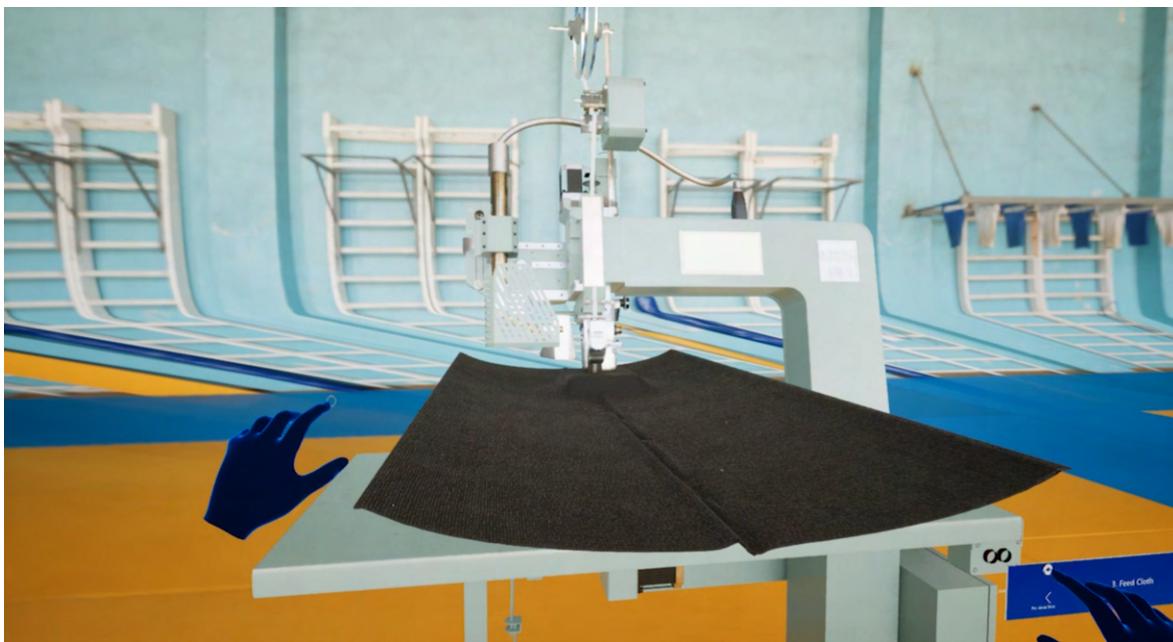
2. Tape Feeding



Tape feeding is the process of setting up the tape for the seam-sealing. The edge of the tape is taken from the tape spool and pass it through different support rollers till the end of the upper roller, as this process is manual and requires extreme precautions it will not be accurately simulated hence we made it automated, where the tape is passed through

multiple support roles and eventually at the upper-roller section. The user can get a basic idea of how it's been done.

3. Cloth Feeding:

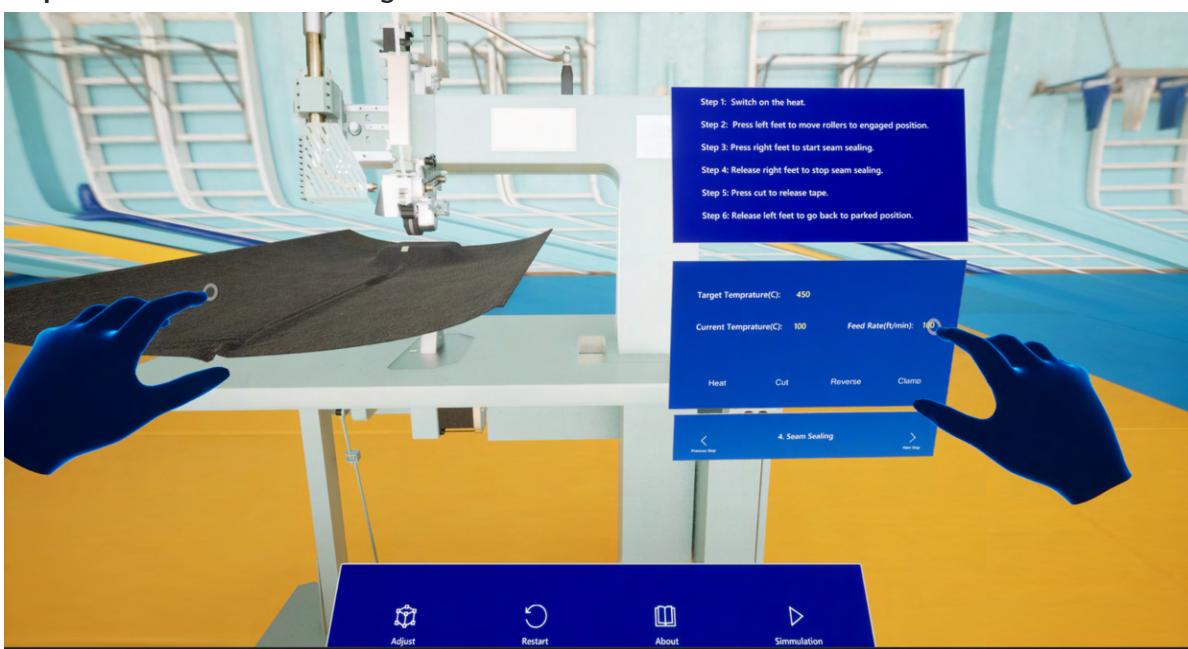


A high poly mesh is used to simulate cloth physics as accurately as possible. For interacting with the cloth user can only touch specific parts of the cloth, It was done due to the limitations of the processing power.

4. Seam-Sealing:

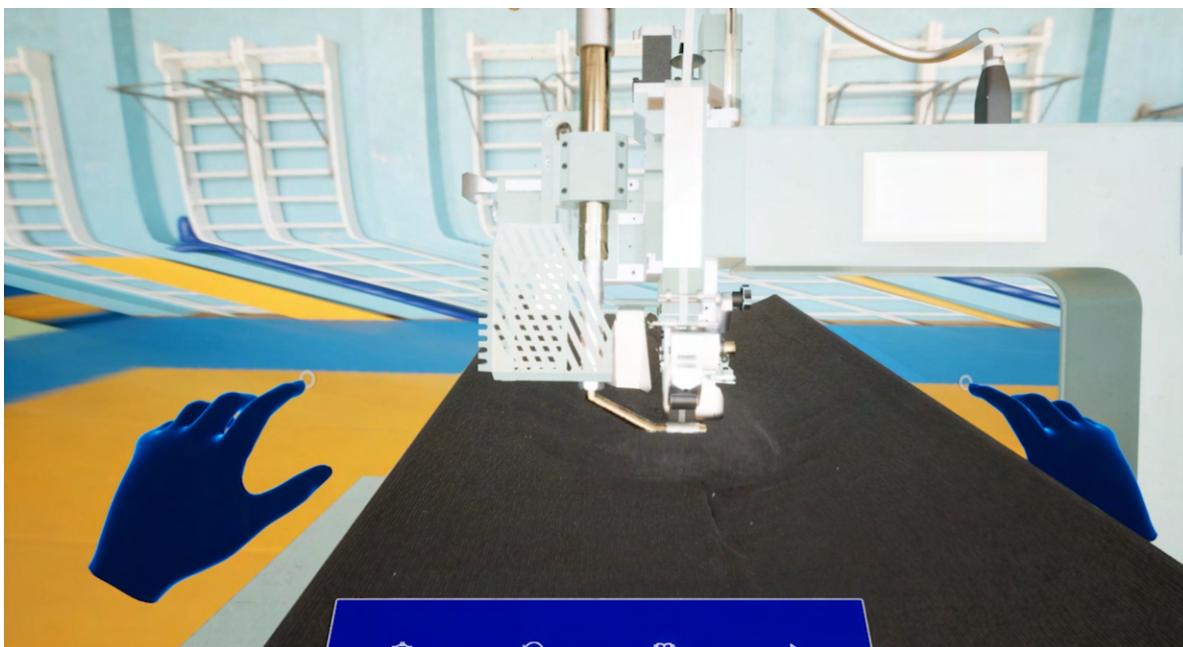
This is where the actual training begins, to make it easier to grapes we break it down in a stepwise process.

Step-1: Switch on the heating.

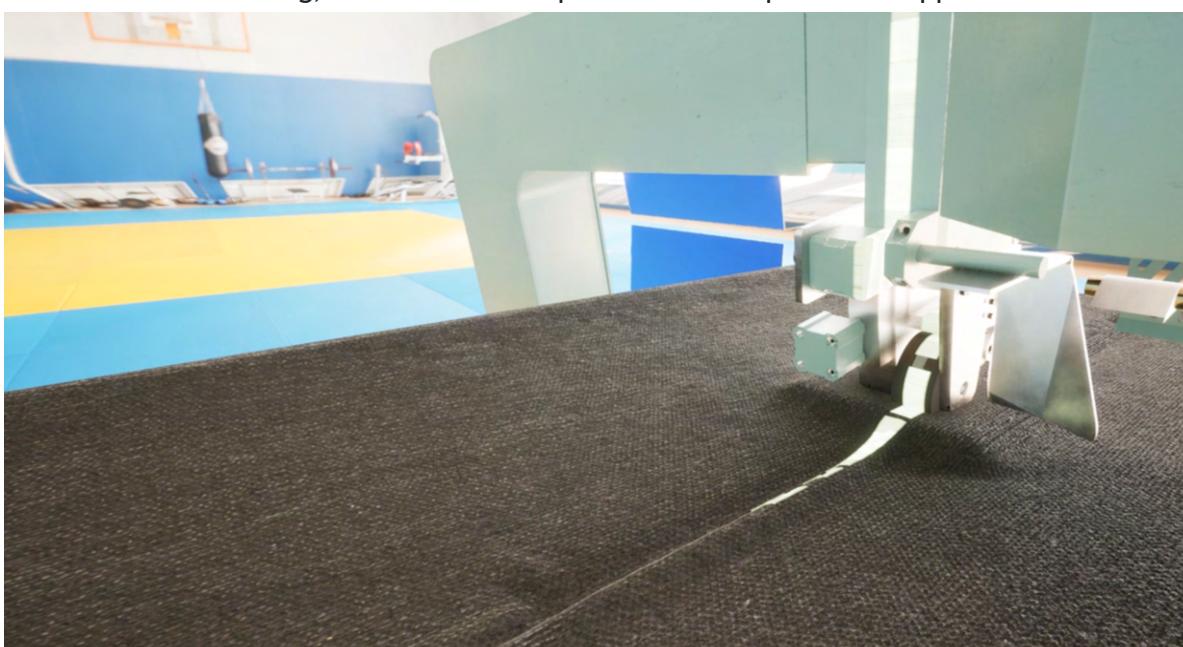


Step-2:

- This is the process of seam-sealing of the fabric, Where the user will be using an HID (Human Interface Device) aka foot paddles to control the machine.
- By default, the machine is in an idle position.
- User will press the Left-Foot which set the Upper Roller part to come down and Nozzel will come to engage position.

**Step-3:**

Now the user will support the cloth using his/her hands and press the Right-Foot and the rollers will start moving, the cloth will be pulled in and tape will be applied to the cloth.



Step-4:

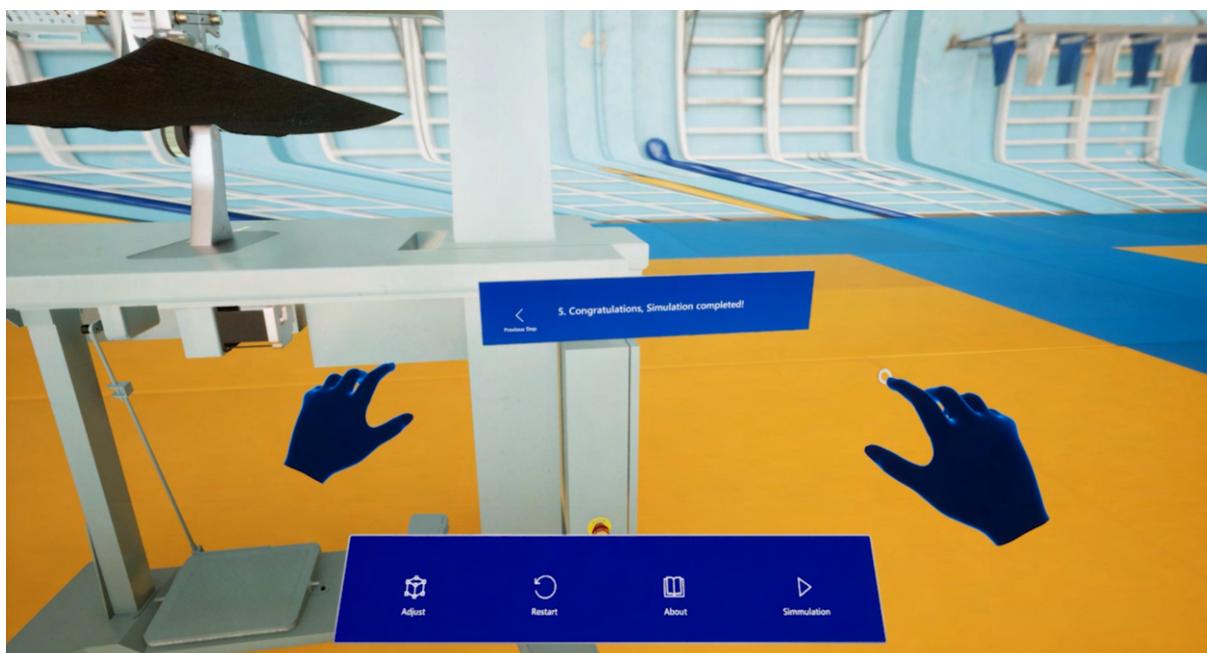
Now the user will release the Right-Foot which stops the roller.

Step-5:

Now he will be pressing the cut switch to cut the tape.

Step-6:

Finally the user will release the Left-Foot which brings the machine back to the idle position.

5. Congrats !!!

And this is where we come to the end of the simulation.

Technology Stack:

Hardware

1. HoloLens2:



The Microsoft HoloLens 2 is a wearable device that allows users to experience mixed reality, which combines elements of augmented reality (AR) and virtual reality (VR). It enables users to interact with virtual objects overlaid in the real-world environment, creating a seamless blend of digital and physical elements.

2. Foot Paddles (pair)



These foot pedals are HID (Human Interface Device) which often have multiple switches or buttons, allowing users to assign different functions or commands to each pedal. They are commonly used in various professional settings where

hands-free or ergonomic control is required such as foot paddles of the Seam Sealing Machine.

Software

1. Unreal Engine v5.0.3 (UE5)



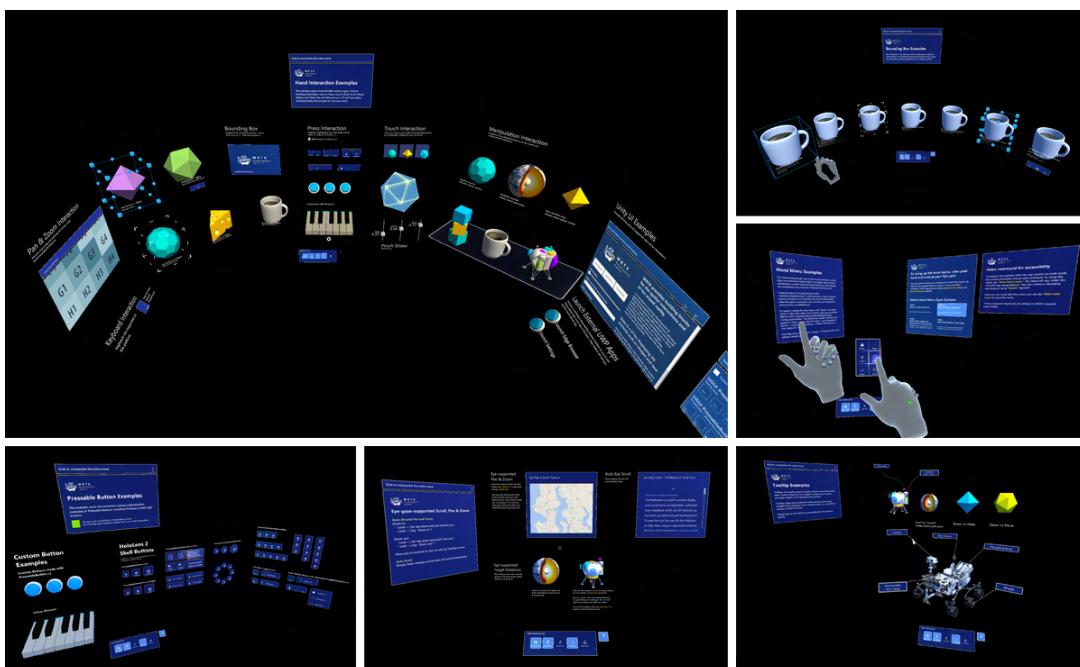
Unreal Engine is a Game Engine packed with professional tools and features and industry-standard for its community, ease of use, and highly accurate simulations. Where logic design is done in the form of node maps which does not require prior knowledge of any particular programming language. It has some amazing features like Lume for global illuminations, Nanites for better polygon processing, and Chaos Cloth simulator, Which turned out to be very effective.

2. Mix Reality Toolkit for UE5



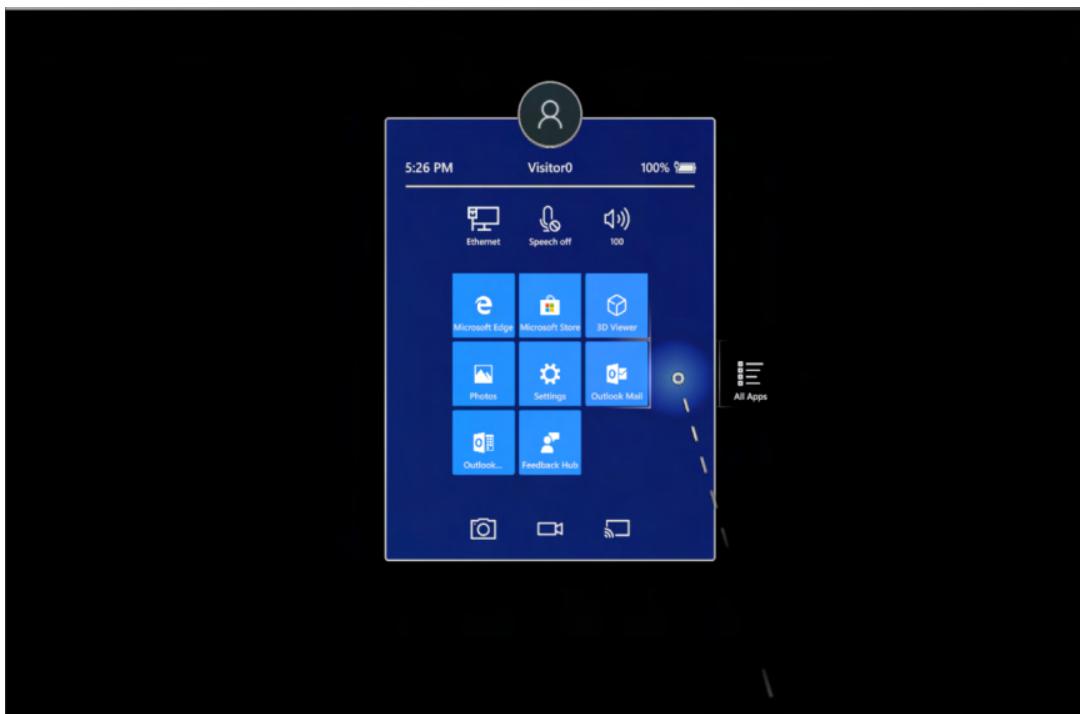
It is a toolkit developed by Microsoft for Unreal Engine to develop applications for Holonese, They have provided amazing [documentation](#), and a [webinar](#) to get the hands-on quickly.

3. Uxtools for MRTK



It is a plugin for UE5 to develop basic UIs using Mix Reality Toolkit for the Hololense application.

4. Hololense Emulator



The HoloLens Emulator lets you test holographic applications on your PC without a physical HoloLens, including the HoloLens development toolset. The emulator uses a Hyper-V virtual machine, which means human and environmental inputs being read by HoloLens sensors are simulated from your keyboard, mouse, or Xbox

controller. You don't even need to modify your projects to run on the emulator, the app doesn't know it isn't running on a real HoloLens.

5. Blender v3.5



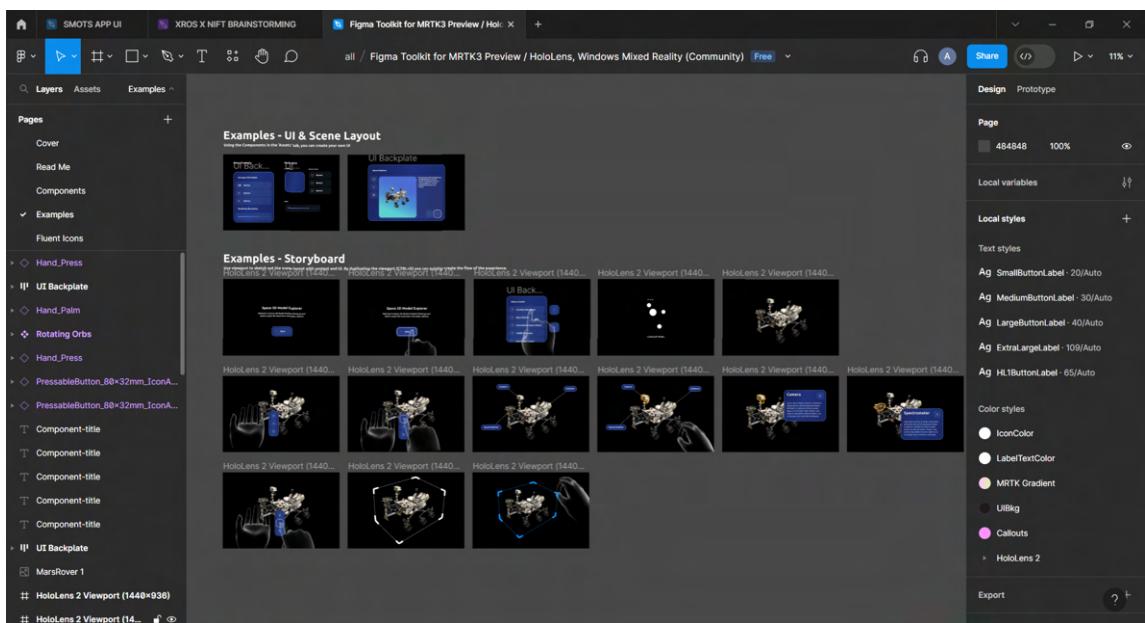
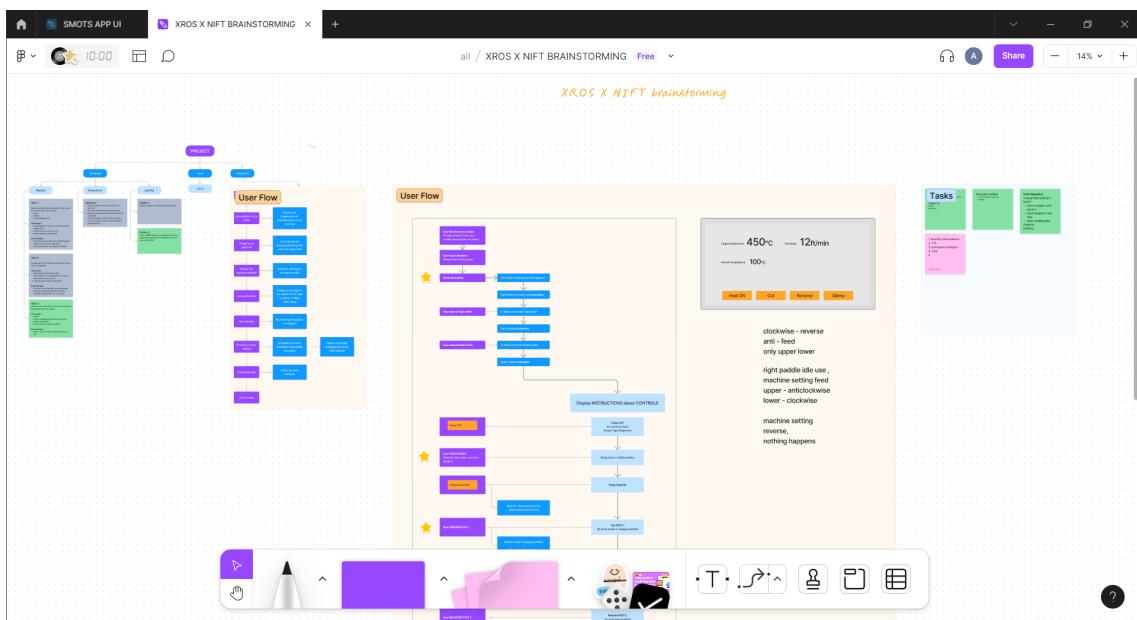
It is a 3D graphics software that can be used for multiple purposes, in this project it was used to work with the 3D Mesh of the machine. We used it to build the armature and some essential mesh for the machine like cloth, tape, machine parts, etc.

6. Substance Painter



It is an amazing tool to design realistic surface materials. The materials are later exported in the form of PBR textures which are easier to work with.

7. Figma



This is a great tool for design and brainstorming. Here we can jam about the ideas and using its MRTK plugins we can design the UIs before developing them in UE5.

8. Git/GitHub



Git is a version control system that was used to track the history of the assets that are being used and the final project was hosted on a public GitHub repo which officially makes it an open-source project.

Goals

1. The simulation is supposed to be as Immersive as possible. (Done)

In the beginning, we were unsure about which platform should we use to train the user. But if we want to make the process as immersive as possible we should use a Head Mounted Device with a camera so the user can interact with virtual objects in an actual environment and we decided to go with Hololense2.

2. The process steps should be beginner friendly and in-depth. (Done)

As mentioned in the project details, to make it easy to use we broke down the process into a series of steps. So no need to wander around the settings of the machine. And the user can understand the process even if he does not have any idea of the working.

3. The virtual replica of the machine should be as detailed as possible. (Done)

The mesh model was provided but it was incomplete so with the reference to the actual machine that was visited by the other fellows and collected the photos and videos of the working of the machine and we got an idea of how the machine should look like,

- The motion of the parts should be accurate as well, So we design the armature for the machine to move the specific parts together with IK-constrained motion.
- The materials were designed in the form of PBR Textures.
- UE5 has the Lumen system for global illuminations which makes the rendering of the materials realistic in real time.

And that's how we were able to achieve the realistic look of the machine.

4. Human interaction with virtual objects should be accurate and smooth. **(Done)**

- The motion detection algorithm of the Hololense is accurate enough to detect the movement of human hands.
- The UxTools of MRTK are designed in such a way that they can record the interaction accurately. And its plugins were working precisely.

5. Cloth physics should be accurate. **(Done)**

This was our biggest concern while developing the application, We were initially going to use Unity for the app development but when we compare the cloth physics simulation quality of Unity and UE5, the Chaos Cloth simulation of UE5 was a clear winner. And we developed the entire application on UE5 and we don't regret the choice that we made.

6. As much Interaction with the cloth as possible. **(Almost)**

We tried to make the cloth interact with the hand but due to the high computation it makes the simulation lag, We allowed only specific areas of the cloth that would be interactable with the hands.

7. Simulation with different fabrics with tape curved tape paths. **(Future Aspect)**

Initially, we decided that if we will able to make the cloth interaction seamless then we can provide the functionality to change the cloth material parameters to the user but it turns out to be much more complicated. Whereas the curvature of the tape path highly depends on the hand movements and a lot of practice, which had to be trained practically.

Contribution

For me, the idea of the project was not that much clear before the joined but by the time I get to know about the size and requirements of the project, which cannot be done single-handedly and requires the expertise of multiple domains. For me, I was quite good with 3D Modeling and UX/UI designing.

The goal of the realistic look of the machine was assigned to me, So I did my best to combine my knowledge and research to represent the look.

1. Mesh

The mesh model was provided but it was incomplete so with the reference to the actual machine that was visited by the other fellows and collected the photos and videos of the working of the machine and we got an idea of how the machine should look like, So designed missing parts of the machine in Blender. You can find my work in my devlogs. And the final mesh files can be found in the GitHub repo.

2. Armature

The machine was supposed to move a few of its parts and due to its high LOD it was quite difficult to tack multiple parts at the same time in Unreal Engine so I came up with the idea to build the armature of the model and assign it to the model so using the particular bones and IK constrains it was easier to move the machine parts.

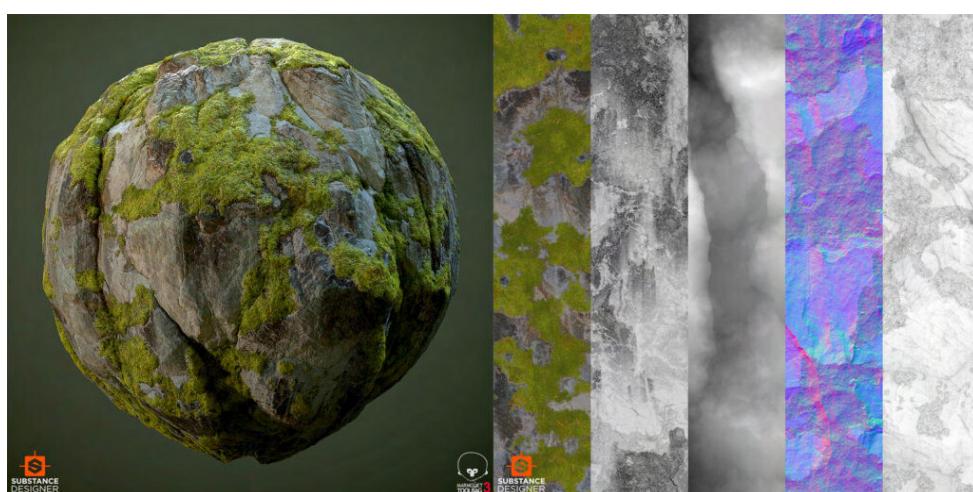


Here you can see the highlighted arrows are bones to control the movement of the machine.

3. Material

Designing material was an important part of for a virtual object to make it look realistic. Blender comes with a lot of features along with material design as well but the materials can not be directly used in UE5. So I found a way efficient method to achieve this.

- PBR textures



PBR stands for **Physically Based Rendering** In which the material of an object is a collection of different texture maps

- **Diffused Map:** The one with the color information.
- **Reflection Map:** The one with the reflection data using which the reflections can be calculated much faster whereas conventional ray-tracing requires the mesh displacement.
- **Height Map:** The one with the height data is also known as the **Displacement Map**.
- **Normal Map:** The one with the normal data of the mesh to simulate bumps without deforming the actual mesh.

And I found the method of sharing the materials but then I came to know about **Substance Painter**. Which comes with amazing texture brushes to design your PBR Textures.

4. Lighting

Even a perfectly designed mesh can look worthless if lights are not set properly. We had multiple options to set up lighting for the environment. But this is a Simulation application for Hololense the lighting should be close to realistic. So instead of setting up the environment with different light setups, I use HDRI.

- **HDRLs**



HDRI stands for **High Dynamic Range Image** which is often used in VFX industries to simulate realistic lights. It is high quality 360° image of a real environment which is later on used as an emissive texture in the virtual scene to simulate lights.

5. Pipeline

As our major tool was Unreal Engine, .blend files are not directly accessible to UE5 so building a pipeline using which we can easily transfer the meshes from Blender to UE5. The blender units are not the same as Unreal units which leads to multiple problems like inaccurate bone weights, Intersection of small parts due to less information. I recognize this problem quickly and found an add-on that can directly export the mesh for UE5 compatible. Which can be found [here](#).

6. UI

I was very new to Unreal Engine so first I completed an online course on it. And now it was my job to design the UX/UI for the Hololense Application.

- So I checked the possible resources and I came to know about Mix Reality Toolkit for UE5 using which we can build the application for the Hololense in Unreal itself so I watched the webinar and came to know more about it.
- I used Figma to design the UI using the MRTK [toolkit for Figma](#) and designed the UI in a [Figma file](#).
- I developed the UI blueprints in UE5 for the UI of the application. Which you can see in the video.

7. Project file management

The file management was not common file-based, Because the size of the project file was quite big, and tracking its edit history was quite complicated.

- We decided to work on individual .uassets (Assets of Unreal Engine) files and later we combined all of them in a single .umap in the final project. Which gives the individual freedom to test anything you want.
- The size of the project won't allow us to upload on GitHub so I came up with a hybrid solution of updating the assets and tools on GitHub to track their update and the project files on Google Drive to share easily with each other.

Management

The video of the prototype was provided by the organization, So we had a basic idea of the final product. We were a team of 6 people where 3 people were selected for **SMOTS** and 3 for **SSMMG** (another proposed project), due to similarities in both the projects our mentor decided to combine us to work parallelly. We all came from different backgrounds, Which made it more exciting to work with.

- Our mentors assigned a specific task to a specific person according to his/her skills and complex tasks to a pair.
- We were also learning along with working on the tasks which require a lot of testing and debugging hence the deadline was always kept soft.
- We had weekly goals to achieve, It may happen that one of us might not be able to achieve them within the given timespan, So we always had some buffer days.

- Our mentor suggested keeping track of your progress so we prepared a worksheet, where we mentioned our weekly derivatives to track the progress of the project. Which can be found [here](#).
- We also decided to record the screen while working on the project to showcase the behind-the-scenes in the form of devlogs. Mine will be found [here](#).
- All of us were always open to accepting our mistakes and sharing whatever we did which enhanced our trust bonding.
- We brainstorm the ideas and approaches of the project on a [FigJam file](#) and distributed the task accordingly.
- We first decided to develop a POC (Proof Of Concept) before developing the actual project. Which took longer than expected eventually delaying the actual project but in the end, we all were happy with the result.

Our management was not top notch but we were committed to it and always had each other's back, Which helped a lot.

Suggestions

- Initially defined tech stack was not enough and appropriate for projects like this, due to which we had to do a lot of research on our own and compare them to select the appropriate one, which took a lot of time. This could have been avoided.
- Although we were provided enough resources the project build was quietly complicated than we expected, It would have been much easier if we had someone with the expertise of the tools that we were using, We always had to rely on the documentation of the tools.
- Our project is designed to run on an actual Hololense, but none of us were able to access it so we had to rely on Hololense Simulator, If we had it we might be able to test the final experience as well.

Mentors

Our mentors were always supportive throughout the fellowship, As the project was going to build from scratch they were always open to any suggestions.

- They kept the timings of the meeting flexible to our availability.
- In every meeting, they note every detail and give their honest opinion about the progress which helps us to improve over time.
- Although they do not have a background in such technology they always show their interest and guide us.
- They allow us to share our ideas and opinions if the initial approach can be optimized.
- They arranged an actual meet to the factory of the Seam-sealing machine which helped us in a lot of ways.

Special Mention

Apart from my supportive team and mentors I also had some help from some external sources,

- [Unreal Dev](#)
- [Unreal Slackers](#)

Also the subreddits like,

- [r/unrealengine](#)

People from these communities were turn out to be very helpful when I felt difficulties while dealing with Unreal Engine 5.

Also, I would like to thank **Harshil Jani** (Osenorth Fellow) and **Ayush Daga** (House of Kriffin Fellow), We regularly meet and share each other problems and learnings.

And in the end, I would like to thank my parents, As it was a WFH(work from home) fellowship I was sharing my progress with them and they always ask questions about it which kept me motivated to work on the project.

Regards

Thank You, FICCI, Reskill, NEGD, Digital-India, META, and NIFT-Delhi for providing such a great opportunity. It was a roller-coaster experience which I did not expect in the beginning. This helped me learn a lot.

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Submitted by
(Duly Signed)

Mentor Name: **Deepak Panghal**
Designation: Assistant Professor, NIFT



Accepted by
(Duly Signed)