



Creating an Augmented Reality Training Simulation for the National Bureau of Standards Reactor using Unity and the Microsoft Hololens

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Introduction

- The NCNR hosts the National Bureau of Standards Reactor
- A 20 MW Nuclear Reactor used for research
- Operators must be vigorously trained
- Current training in classroom with occasional exercises



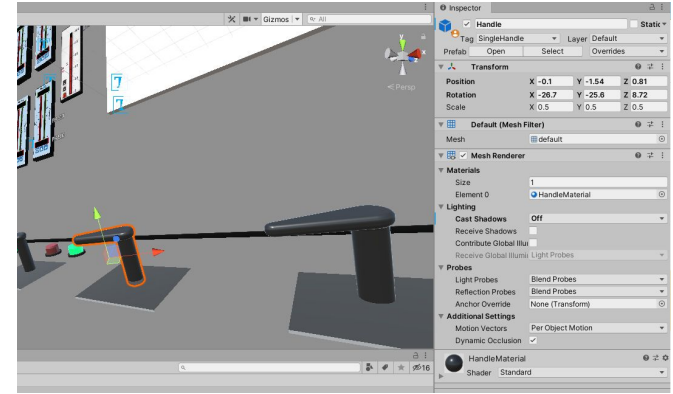
Project Goals

- Create an effective and interactive NSBR training simulator
 - Accurate to the reactor
 - Perform well technically
- Be able to test hypothetical scenarios such as emergency situations
- Be able to update the virtual console
- Portable and easy to access



Technology Used*

- Unity Game Engine with scripting in C#
 - Interface to create and interact with virtual objects on many platforms
- Microsoft HoloLens 2.0
 - AR/Holograms give interactive interface
 - All interactions done with voice, hand and eye gestures

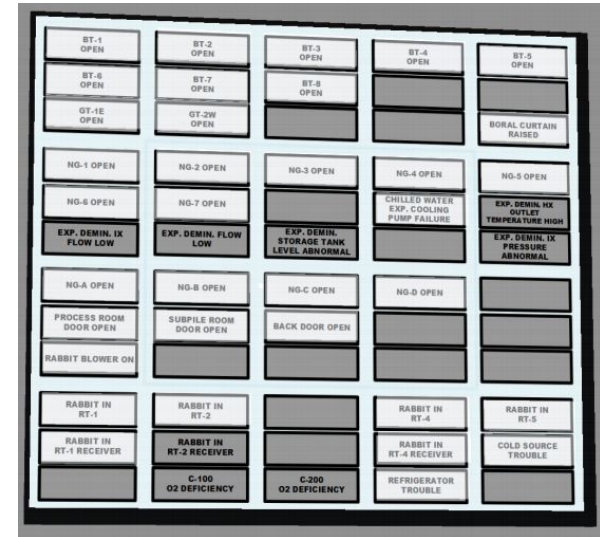
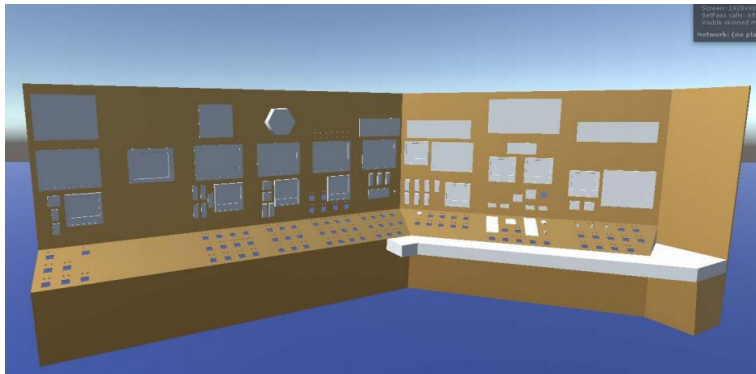


*NIST does not condone or sponsor the use of these brands/products

NIST

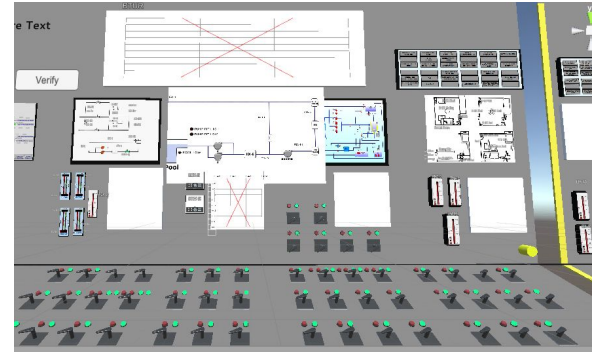
Virtual Reactor Components

- System uses 84 switches, 10 recorders, and 8 screens/displays
- Modelled in various 3D softwares
- Annunciators shown on panel



Component Programming

- GameObjects handled by Unity
- Displays simulated by Chart/Graph Software for Unity
- Interaction of each button/switch updates a value in CSV database to manage states



Programming the Simulation

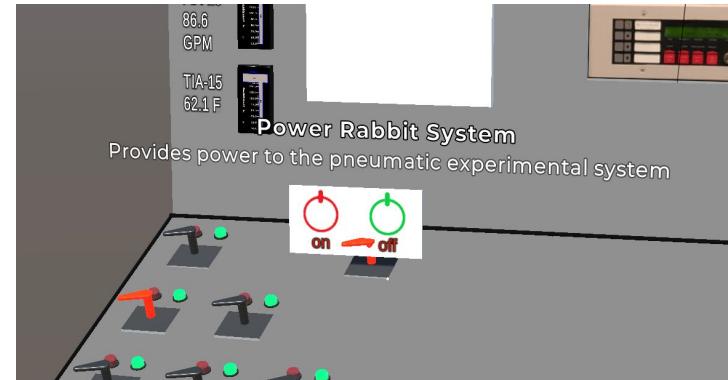
- Used Microsoft Mixed Reality Toolkit API
- CSV Files and C# Dictionaries are used to map switches/buttons to functions & display
- Mapping matrix controls interaction results
 - Each switch mapped to a perturbation

```
Power Rabbit System,on/off,Provides power to the pneumatic experimental system,SwitchRSC,0,Storage Pool
Neutron Guide Control Power,on/off,Provides power to the neutron guide shutters,SwitchNGCP,0,
Storage Pool Pump #1,on/off/stby,Provides power to storage pool pumps,SwitchSPP1,5,
Storage Pool Pump #2,on/off/stby,Provides power to storage pool pumps,SwitchSPP2,5,
Storage Pool IX Booster Pump,on/off/stby,Provides power to IX booster pump,SwitchSPPB,1,
EXP Destin Water Pump #1,on/off/stby,Provides power to the experimental destin water pump #1,SwitchDestinWater1,1,
EXP Destin Water Pump #2,on/off/stby,Provides power to the experimental destin water pump #2,SwitchDestinWater2,1,
Helium Compressor Sec Cooling Pump #1,on/off/stby,Provides power to the Helium Compressor Sec Cooling Pump #1,SwitchHCCP1,1,
Helium Compressor Sec Cooling Pump #2,on/off/stby,Provides power to the Helium Compressor Sec Cooling Pump #2,SwitchHCCP2,1,
He Make Up,open/closed/auto,Does something related to Helium,SwitchM,1,
CO2 Makeup,open/closed/auto,Does something related to CO2,SwitchCO2M,1,
D2O Exp Cooling Iso Valve DW-26,open/closed,Opens or closes the Valve,SwitchDMW26,0,
D2O Exp Return Iso Valve DW-24,open/closed,Opens or closes the Valve,SwitchDMW24,0,
Helium Blower #1 & Discharge Valve HEV-5,on/off/stby,Blows Helium,SwitchHMB1,1,
Helium Blower #2 & Discharge Valve HEV-7,on/off/stby,Blows Helium,SwitchHMB2,1,
D2O Exp Cool Booster Pump #1,on/off/stby,Activates the D2O booster pump,SwitchCB1,1,
D2O Exp Cool Booster Pump #2,on/off/stby,Activates the D2O booster pump,SwitchCB2,1,
Thermal Column Pump #1,on/off/stby,Activates the Thermal Column Pump,SwitchTCP1,1,
Thermal Column Pump #2,on/off/stby,Activates the Thermal Column Pump,SwitchTCP2,1,
CO2 Purge fan,on/off,Activates the CO2 purge fan,SwitchCO2PF,1,Asu System
Emer Tank Make-up Valve DW-48,open/closed,Controls the emergency tank make up valve,SwitchDMW48,1,
Pre-Filter Isolation Valve DW-25,open/closed,Controls the Pre-Filter Isolation valve,SwitchDMW15,1,
Reactor Pump Up Isolation Valve DW-134,open/closed,Controls the reactor pump up isolation valve,SwitchDMW134,1,
#1 Storage Tank Pump Outlet Valve DW-14,open/closed,Controls the Storage Tank Pump Outlet,SwitchDMW14,1,
#2 Storage Tank Pump Outlet Valve DW-15,open/closed/stby,Controls the Storage Tank Pump Outlet,SwitchDMW15,1,
HE-2 Sec Inlet SCV-12,open/closed,Controls whatever,SwitchSCV12,1,
D2O Stor Tank Pump #1,on/off/auto,Controls the D2O storage tank pump,SwitchSTP1,1,
D2O Stor Tank Pump #2,on/off/auto,Controls the D2O storage tank pump,SwitchSTP2,1,
Dilution Exhaust Fan EF-2,on/off/stby,Controls the dilution exhaust fan,SwitchEF2,1,Ventilation System
```

Storage Pool Pump #1,on/off/stby,Provides power to storage pool pumps,SwitchSPP1,5,				
Storage Pool Pump #2,on/off/stby,Provides power to storage pool pumps,SwitchSPP2,5,				
Name	States	Description	Unity Name	Type

Educational Use

- Switch Instructions/Info
- Procedure Steps Listed/Timed
- Generates Report
 - Total Time
 - Total Mistakes
 - Switch/Annunciator Error Percentages



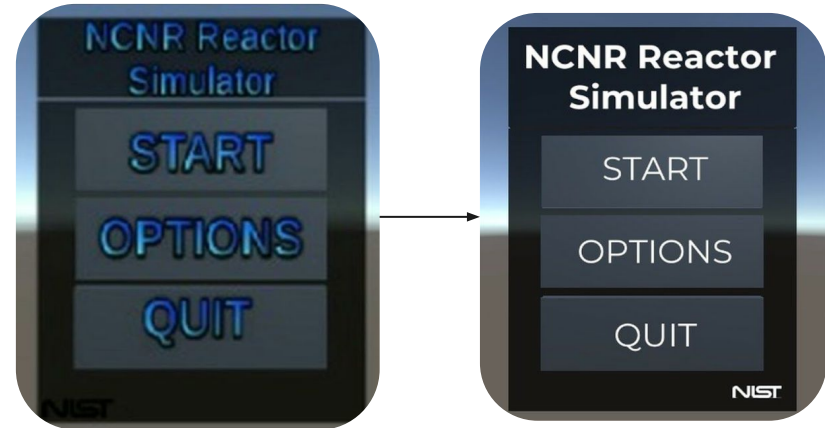
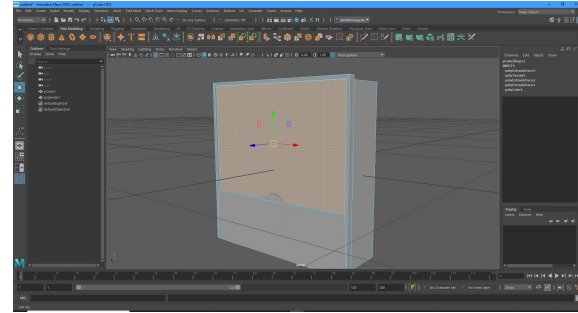
Operator Interaction

- Scenarios consist of:
 - Startup procedure
 - Fire on Console
 - SCRAM Procedure
 - Free Access
- Realtime reactor values are taken from a server to feed into simulation
- 1:1 Scale with Physical Movement



Personal Work

- Legacy Project Starting from 2017/18
- Contributing work on:
 - New Models
 - Better UI
 - Bug Fixes
 - Code Organization



Future Work

- Bug Fixing
- More user friendly interface
- Higher Efficiency
- Ports to other platforms (VR or PC)



Acknowledgements



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**Thank you.
Questions?**

