National Bureau of Standards Reactor (NBSR) Plant State Predictor (PSP)

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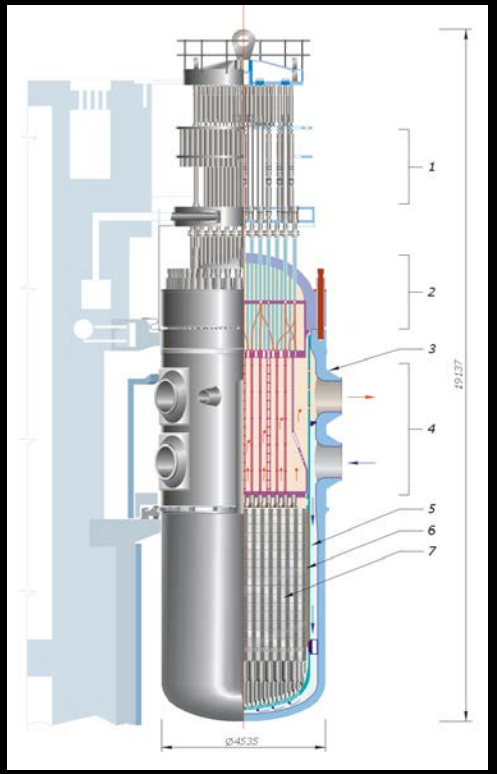
INTRODUCTION

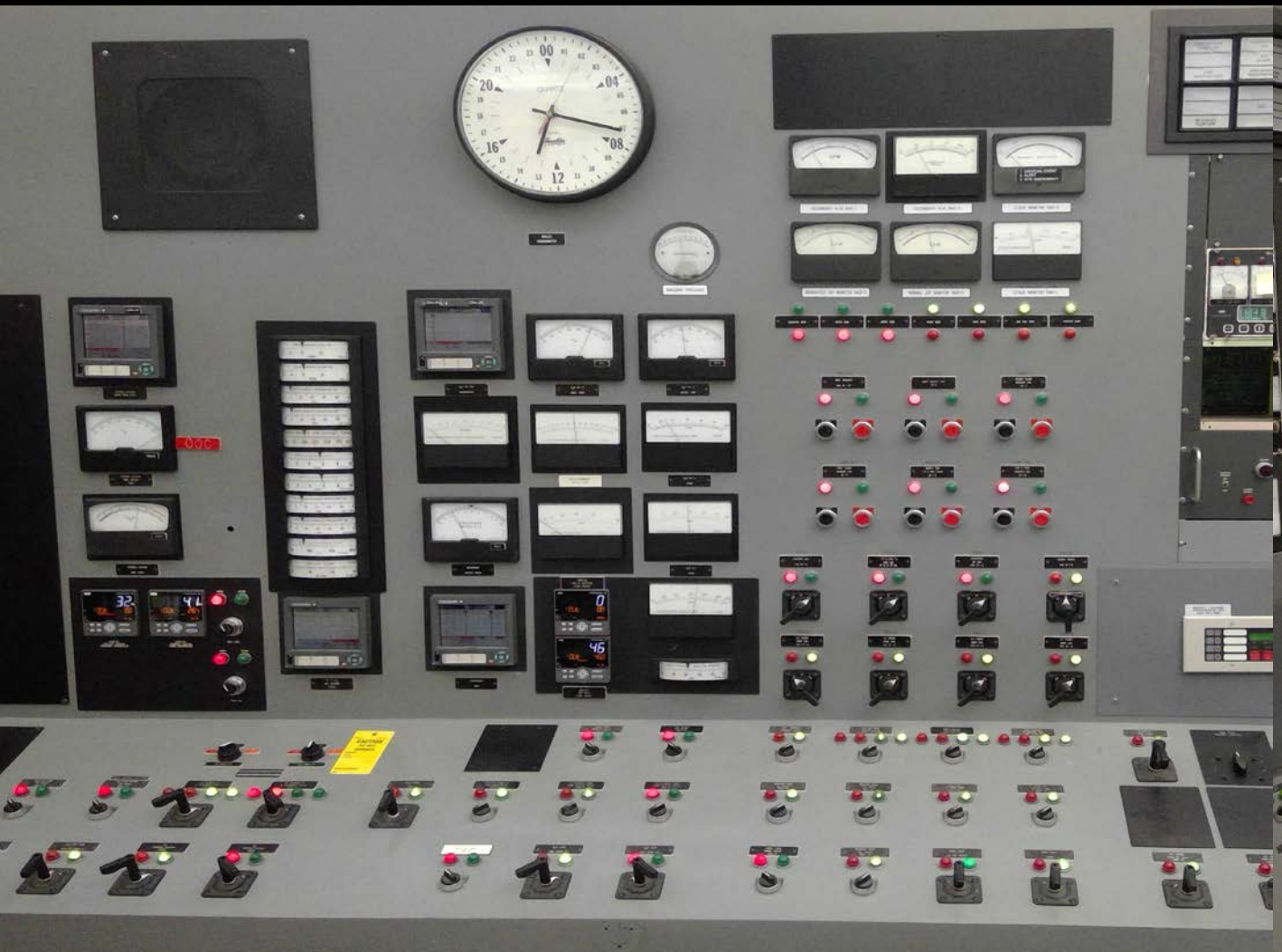
- National Institute of Standards and Technology (NIST) hosts a 20 MW nuclear reactor
- Operators control the reaction of nuclear reactor from the reactor console in the control room
- NBSR reactor is currently undergoing console upgrades
- The NBSR Reactor Plant State Predictor is part of a larger project



GOALS

- Create The NBSR Reactor Plant State Predictor (PSP)
- Implement the components and functionality of the physical console that would behave comparable to the NIST NBSR
- Operators can wear a HoloLens to view and interact with virtual console
- Also develop a mixed reality holographic experience in HoloLens environment

WHAT IS A CONSOLE?



WHAT IS A HOLOLENS?

- known as a mixed reality headset
- Holographic computer
- Runs on windows 10
- The holograms help in training the operators
- Advantages:
  - Responsive to the presence of people
  - Provides a modular and effective environment
  - Virtual console can be operated anywhere

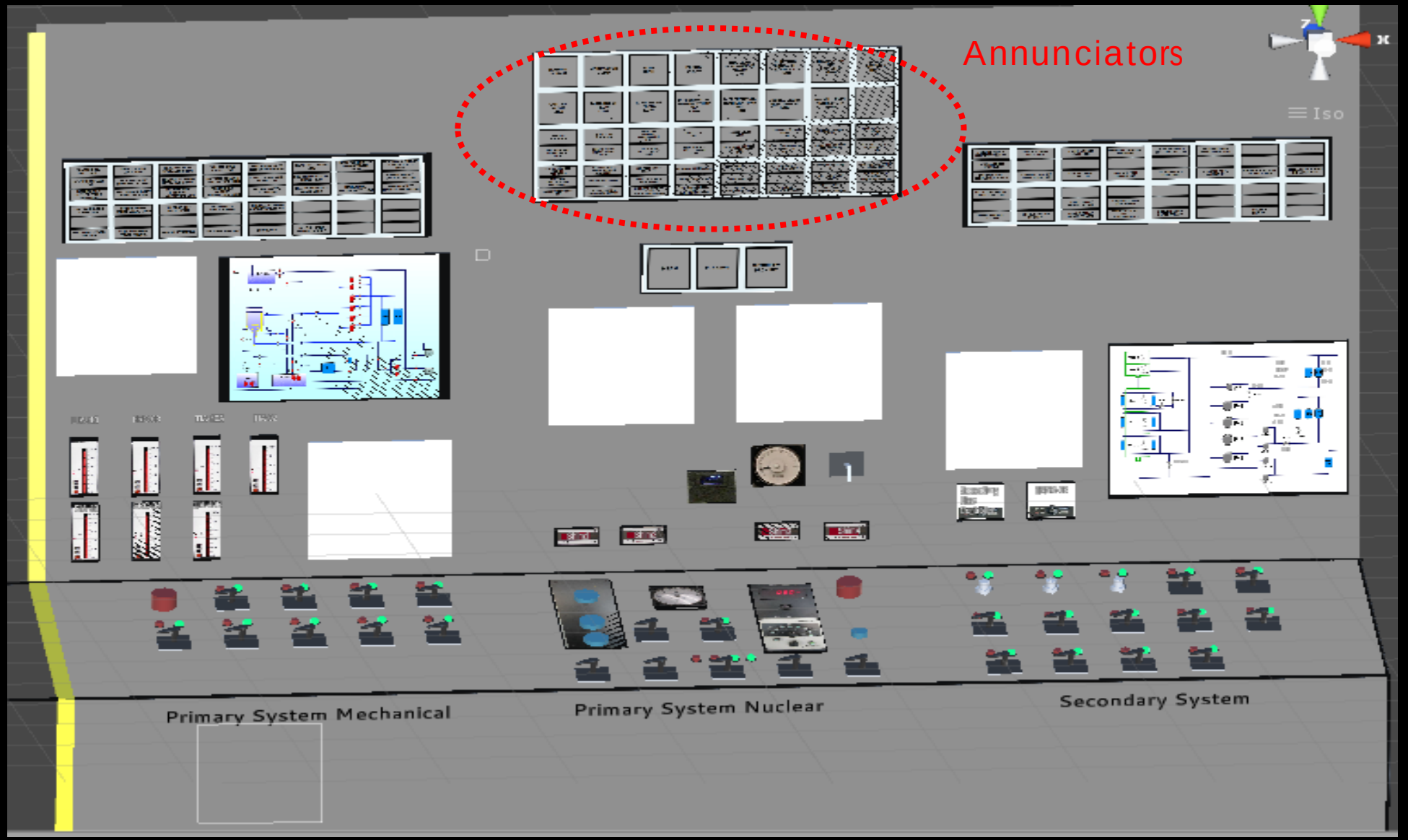
HOLOGRAMS

- Objects made of light and sound that appear in the world around you, just as if they were real objects
- The hologram is a realistic reactor operation console

DEVELOPMENT PROCESS

unity

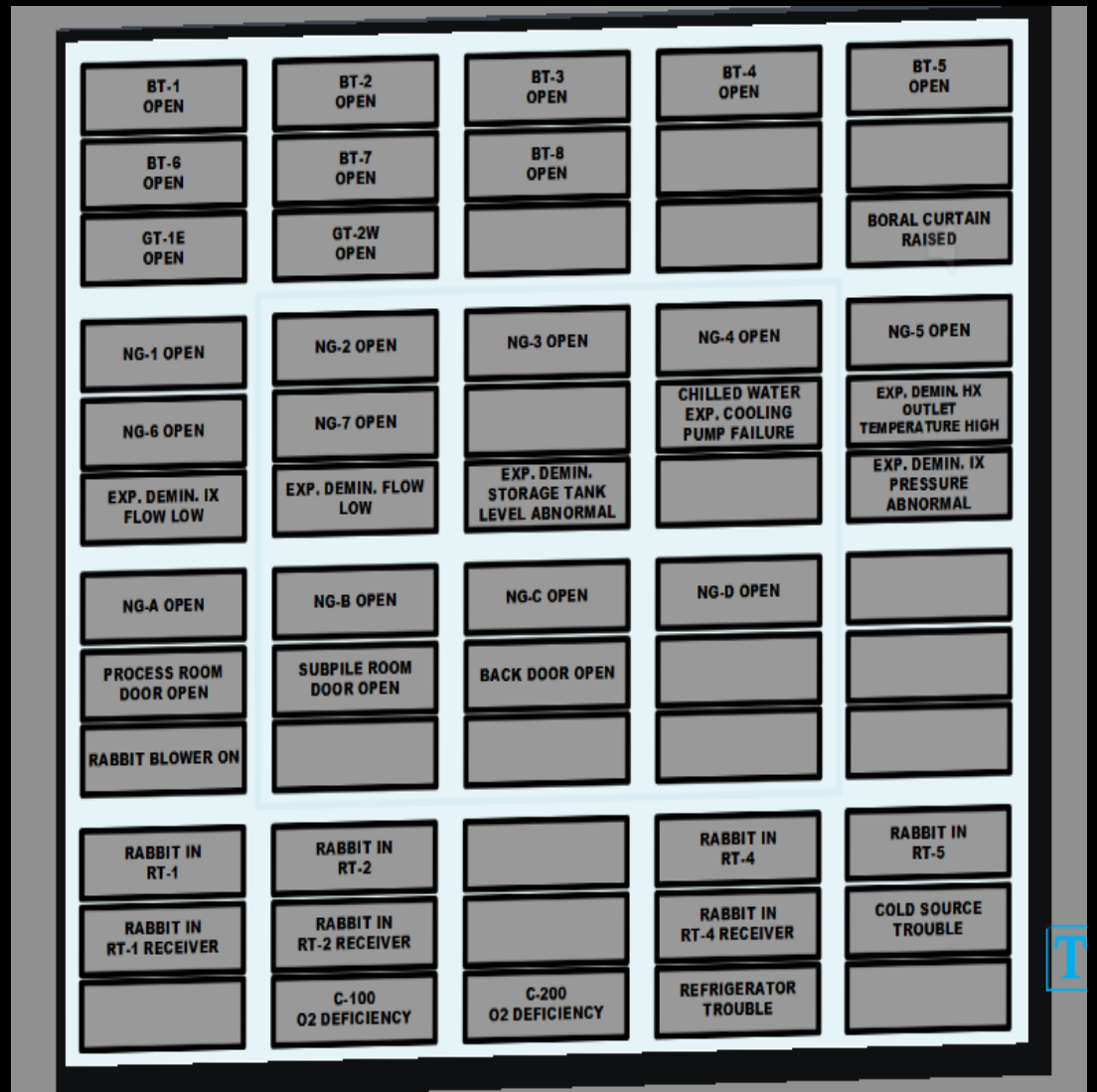
VIRTUAL CONSOLE



ANNUNCIATORS

- Annunciators are alarms based on plant condition
- The trending changes are increased in reactor systems, such as setting alarm points
- Worked on alarms to be turned on and off at a given alarm condition
- Worked on scheduled alarms that actuate at a given time

BEFORE



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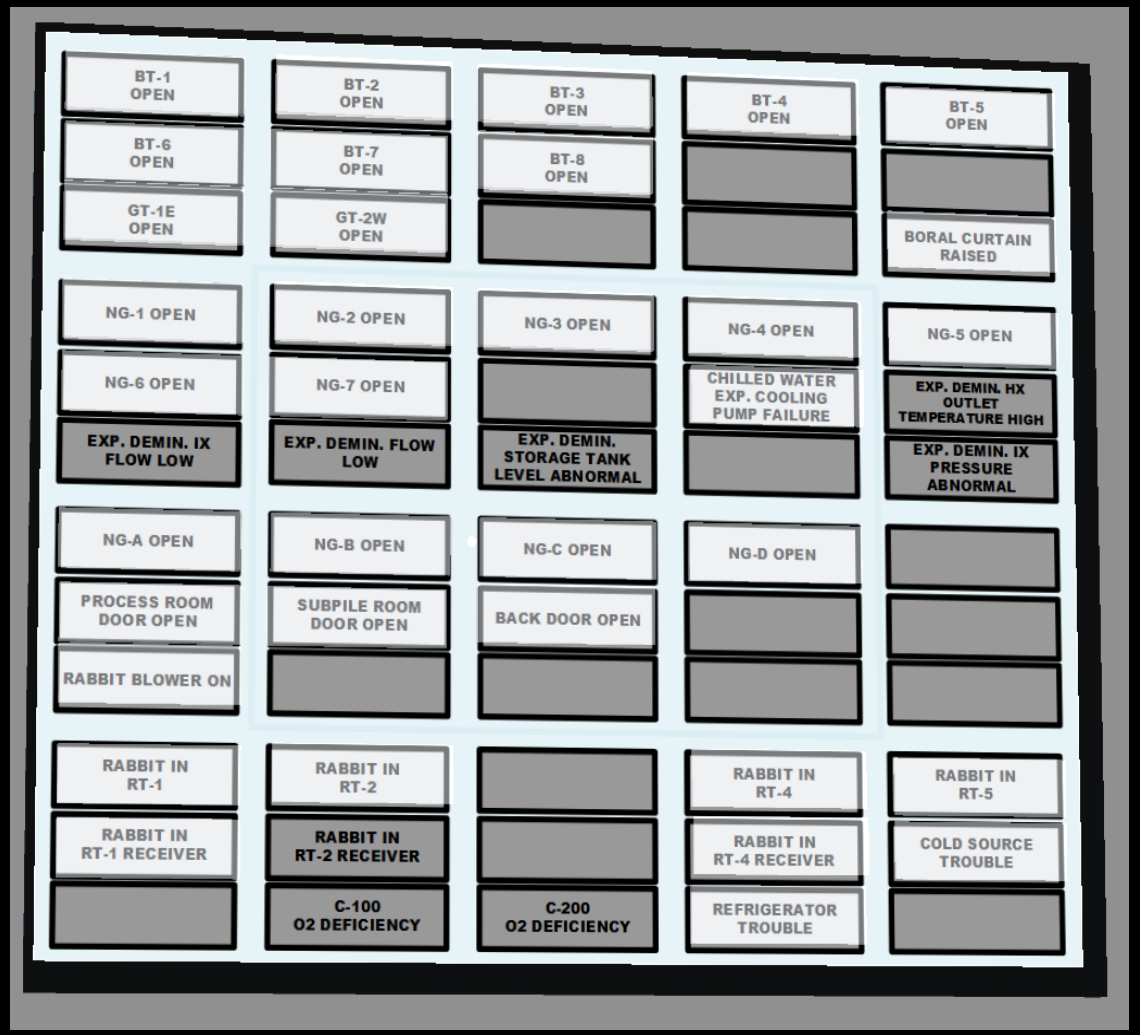
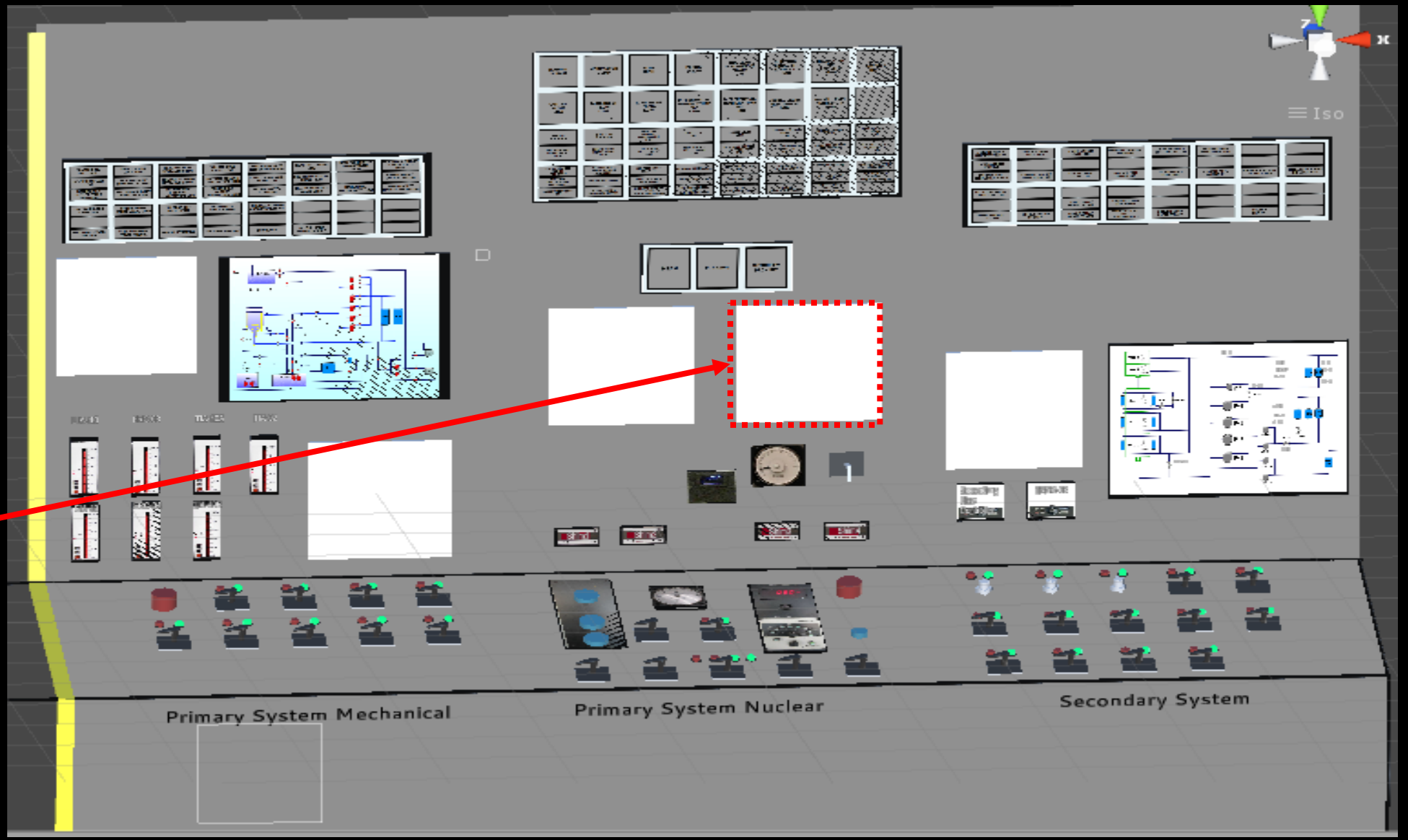


VIRTUAL CONSOLE

Reactor Power

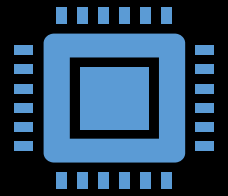


PLANT STATE PREDICTOR

- Purpose is to use real data from the NIST NBSR reactor to teach a machine which would predict reactor states based on the user input
- Use the data to predict the values through neural networks

neural network is represented by a series of layers that work much like a living brain

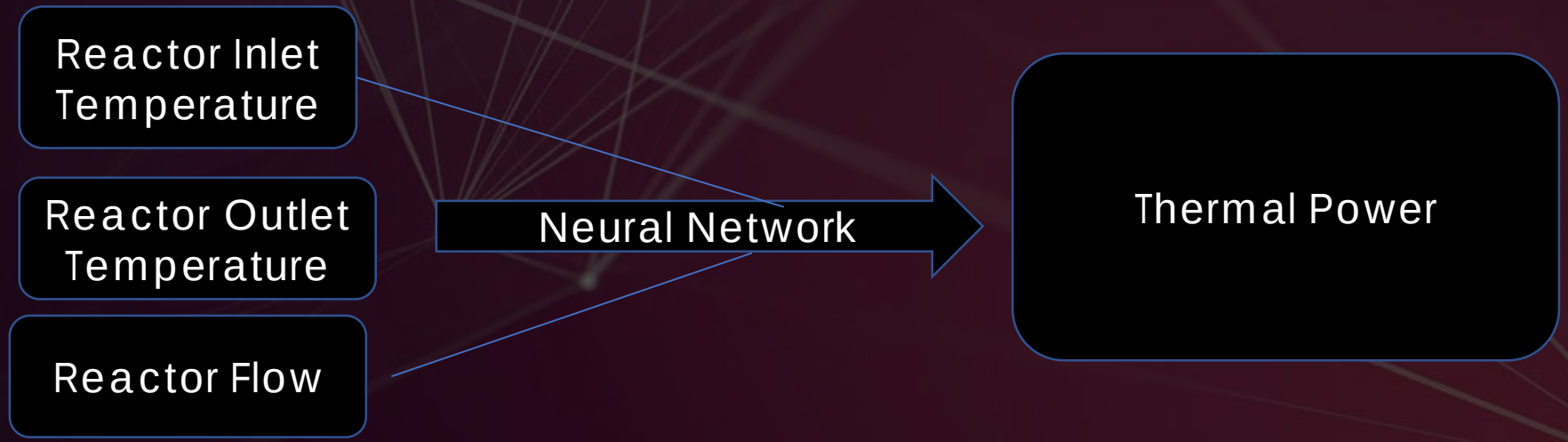
The neural engine was trained using historical operation data



neural network class in python to make accurate predictions

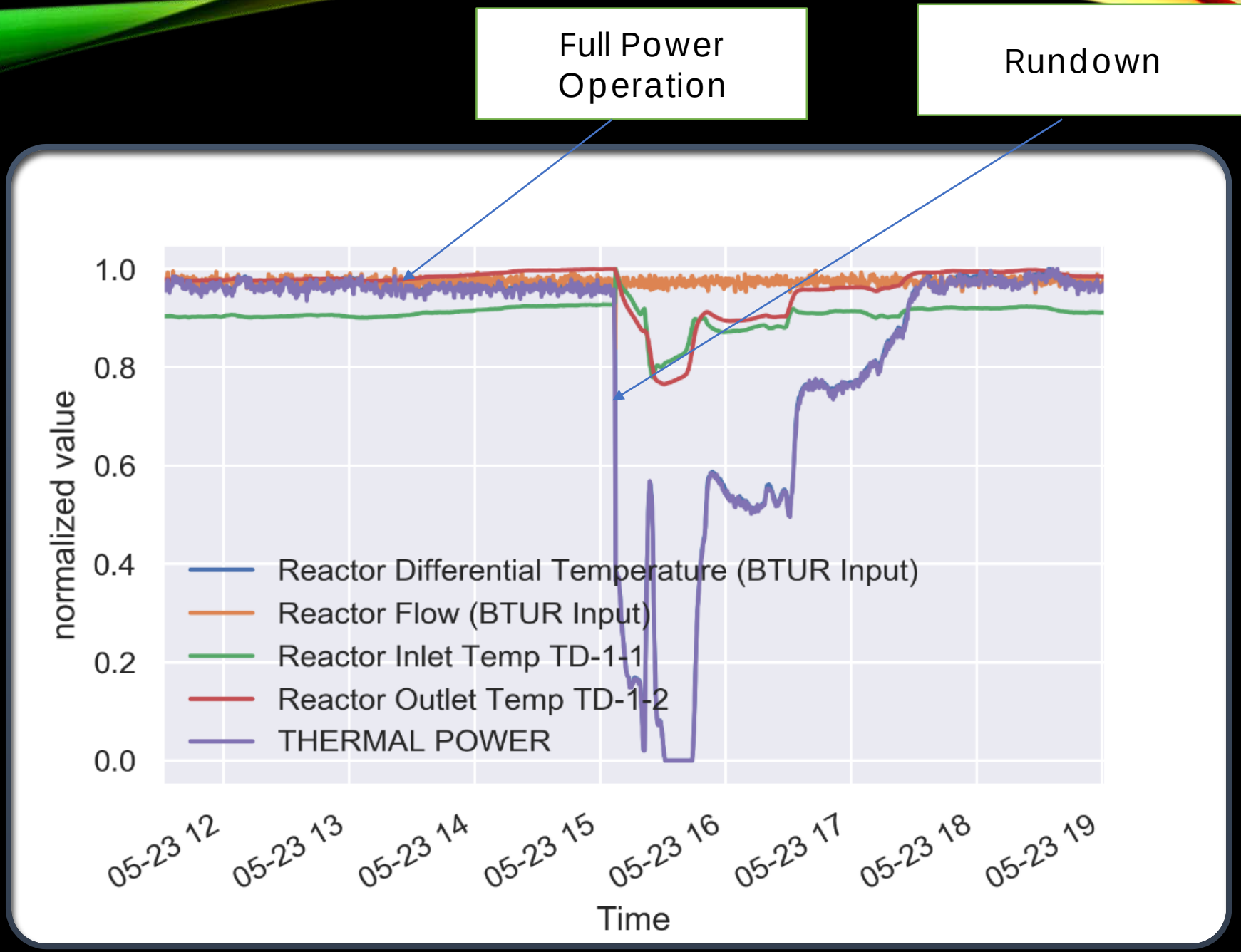
NEURAL NETWORK

- Supervised learning technique utilizing labeled data:
  - Feature vector $X_i = [x_1, x_2, \ldots x_n]$
  - Label y_i
    - Thermal Power
- Function approximation
  - Training learns f*(X) → y
- Regression is the task of predicting a continuous output



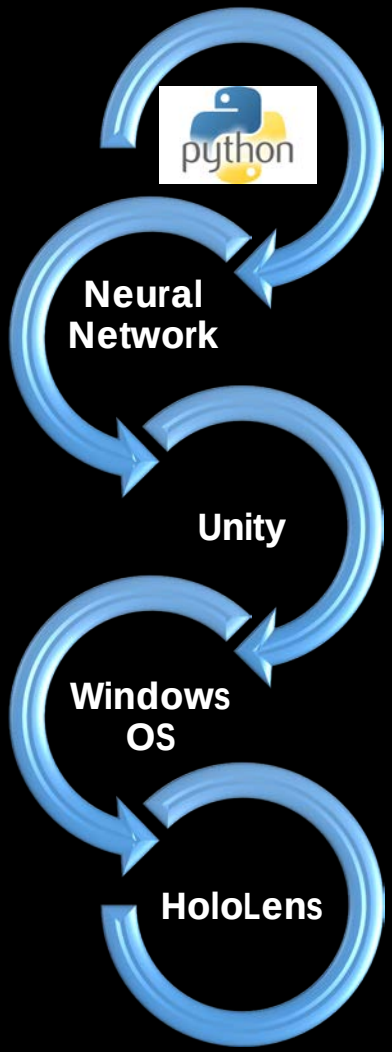
NIST NBSR REACTOR DATA

- Data of NBSR reactor when the rundown occurred on May 23rd
- Normalized Values
- Weight is typically 0-1
- To compare the relative changes



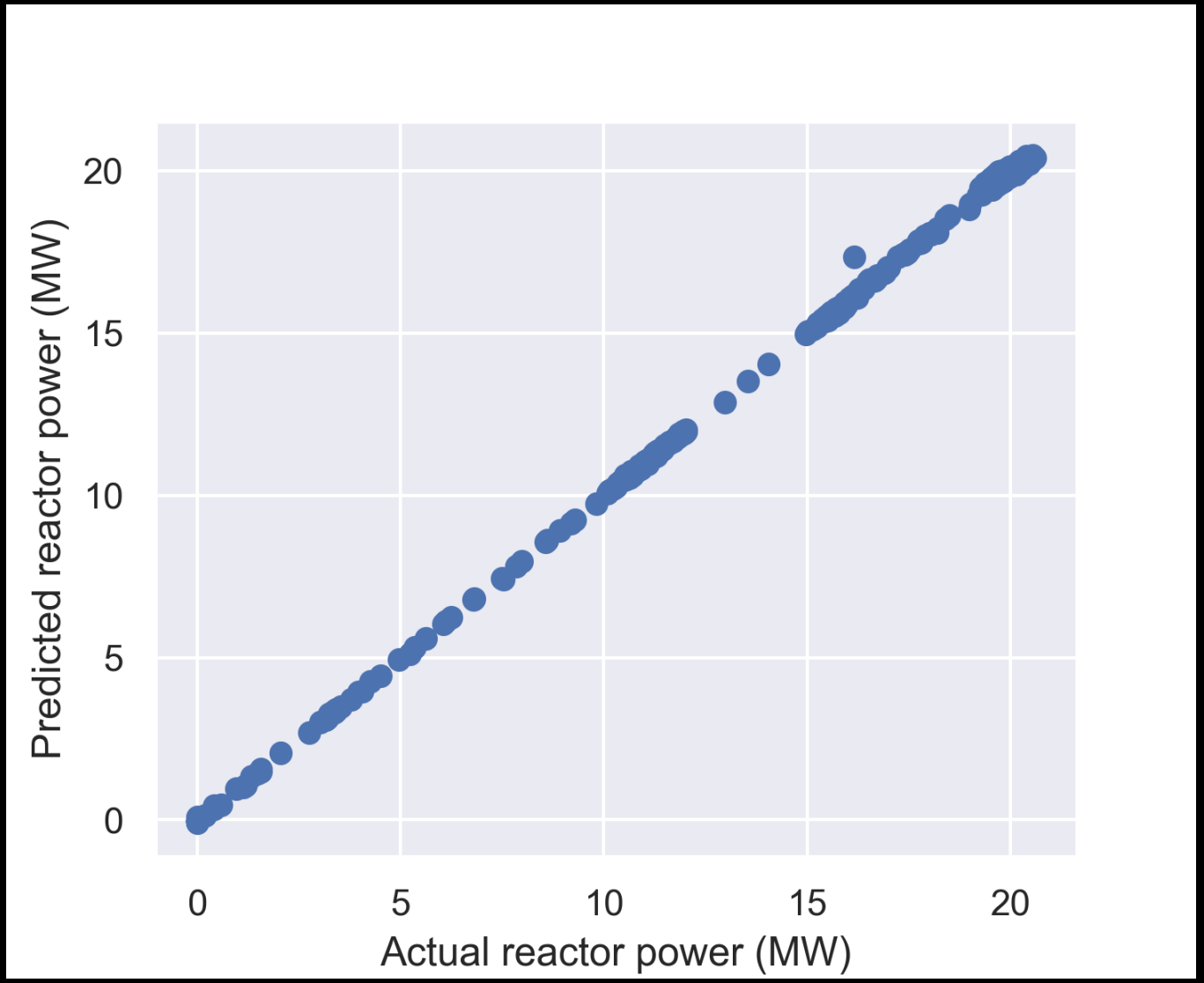
WHY ARE WE PREDICTING THE DATA?

- So we can have a more realistic simulator
- Neural networks were implemented in Python with Keras library
- To deploy the data through neural networks to HoloLens for the operators to be trained



RESULTS

- Demonstrated neural networks for PSP
- Generated a prediction for each element on the test set
- Actual and Predicted values of Thermal power



CONCLUSION

Goal: The operator's interactions should result in feedback that are alike the real reaction operation

→ Annunciators were implemented

Goal: Have an intelligent, responsive data trend analysis and tracking system

→ Demonstrated neural networks for Plant State Predictor

FUTURE WORK

- Train and test data for all the other factors
- In order to deploy from Python to HoloLens, the Visual Code will be used
- Add extensions to create a Python development environment

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