Virtual Automation Lab using Unity3D and OpenModelica

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Agenda

1. Introduction to Virtual Automation Lab (VAL)
2. Components of VAL
3. System Architecture
4. Demonstration

1. Introduction to Virtual Automation Lab (VAL)

Motivation

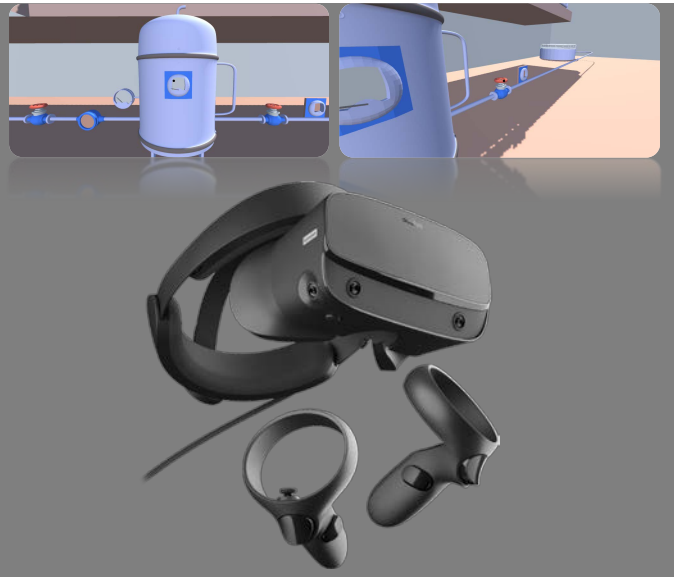
1. Access to industry is not easy for engineering students and lack of it is creating skill gap between industry and academia.
2. Virtual Automation Lab is a project aimed at bridging that gap.
3. Non immersive simulators have limited applications:
   a. Even best of the simulators can not give realistic experience of an industry.
   b. Conventional simulators teach system complexity and not usability.
4. A Virtual Reality simulator will allow:
   a. Interactive operation of machines.
   b. Interactive learning of industrial sensors and actuators.
   c. Manual fault detection and correction.
   d. Operation in auto mode.
   e. Trainer-operator setup and evaluation.

Introduction

1. Virtual Automation Lab is a project aimed at building industry grade Virtual Reality experiences of automation industry for engineering students.
2. It includes:
    a. A Virtual Reality simulated environments created using Unity 3D,
    b. Process simulations running on OpenModelica and
    c. PLC/HMI interface running on CodeSys.
3. Each experiment will have two modes of operations: Auto/Manual
4. Manual Mode Operation:

    In manual mode the inputs to the process simulation model will come from the user via VR hand held controllers.
5. Auto Mode Operation:
    a. Control signals will come from PIDs tuned by the user.
    b. Resulting changes will be visible in VR environment and HMI in both modes.

Architecture

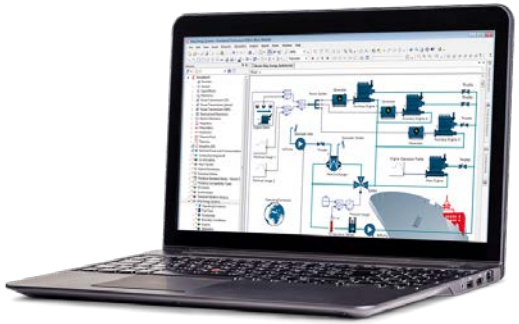


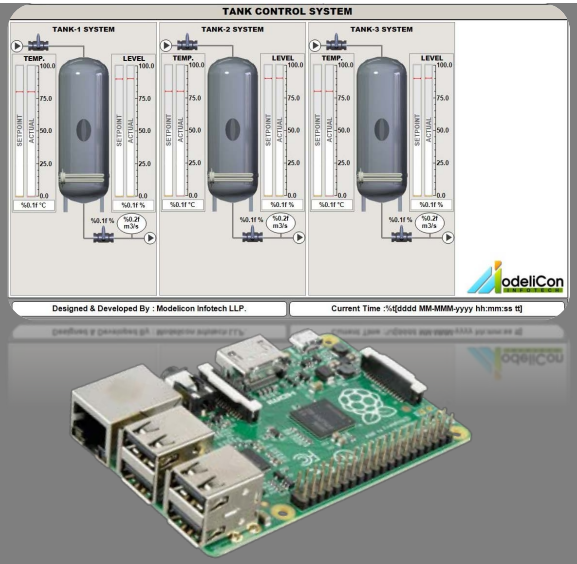
Oculus Rift S

- 3D VR model
- Manual valves and analog indicators
- Socket link with OpenModelica
- UDP server
- VR development in Unity 3D
- 3D models design in blender

OpenModelica on PC

- Mathematical Model
- OPC-UA embedded server
- Python OPC-UA client
- UDP client





CodeSys PLC on Raspberry Pi

- PID controllers
- HMI for PID parameters setting and response visualization
- Real time plots
- Auto/Manual switch
- Inbuilt OPC UA Server

ModeliCon INFOTECH OpenModelica RISE

2. Components of VAL (Interacting Tanks Model)

Simulation Model - OpenModelica

1. Model contains three tanks coupled together with one source and one sink tank.

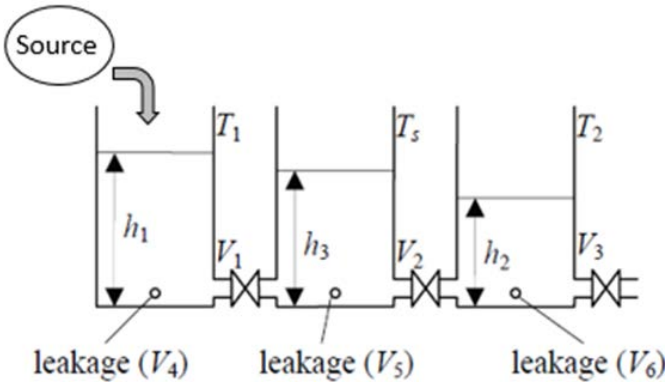


Fig 1. Interacting Tanks

2. Change in tank level or tank temperature of one tank causes disturbances in the system.
3. Valves after each tank are manipulated to achieve a required fluid level and temperature in each tank.
4. Valve control value can either be supplied from a set of PID controllers running in CodeSys PLC in automatic mode or from the VR remote controllers in manual mode.
5. Each tank has a leakage valve as well for removing excess fluid or creating disturbances.

Simulation Model- OpenModelica

Fig 2. Connected Tanks Library: OM library containing definitions of tanks, valves, source and sink

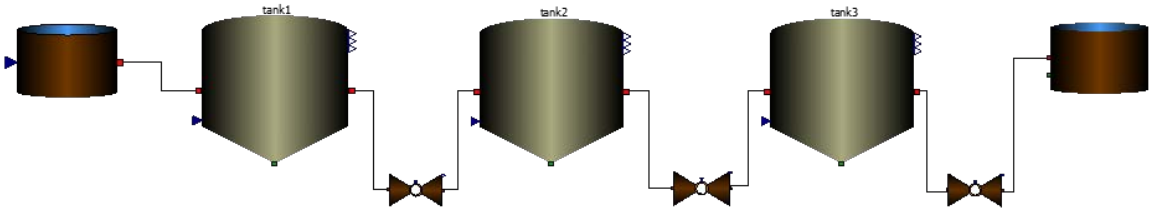


Fig 3. Interacting Tank Model : OM simulation model connecting three tanks via valves

VR Model – Line Diagram

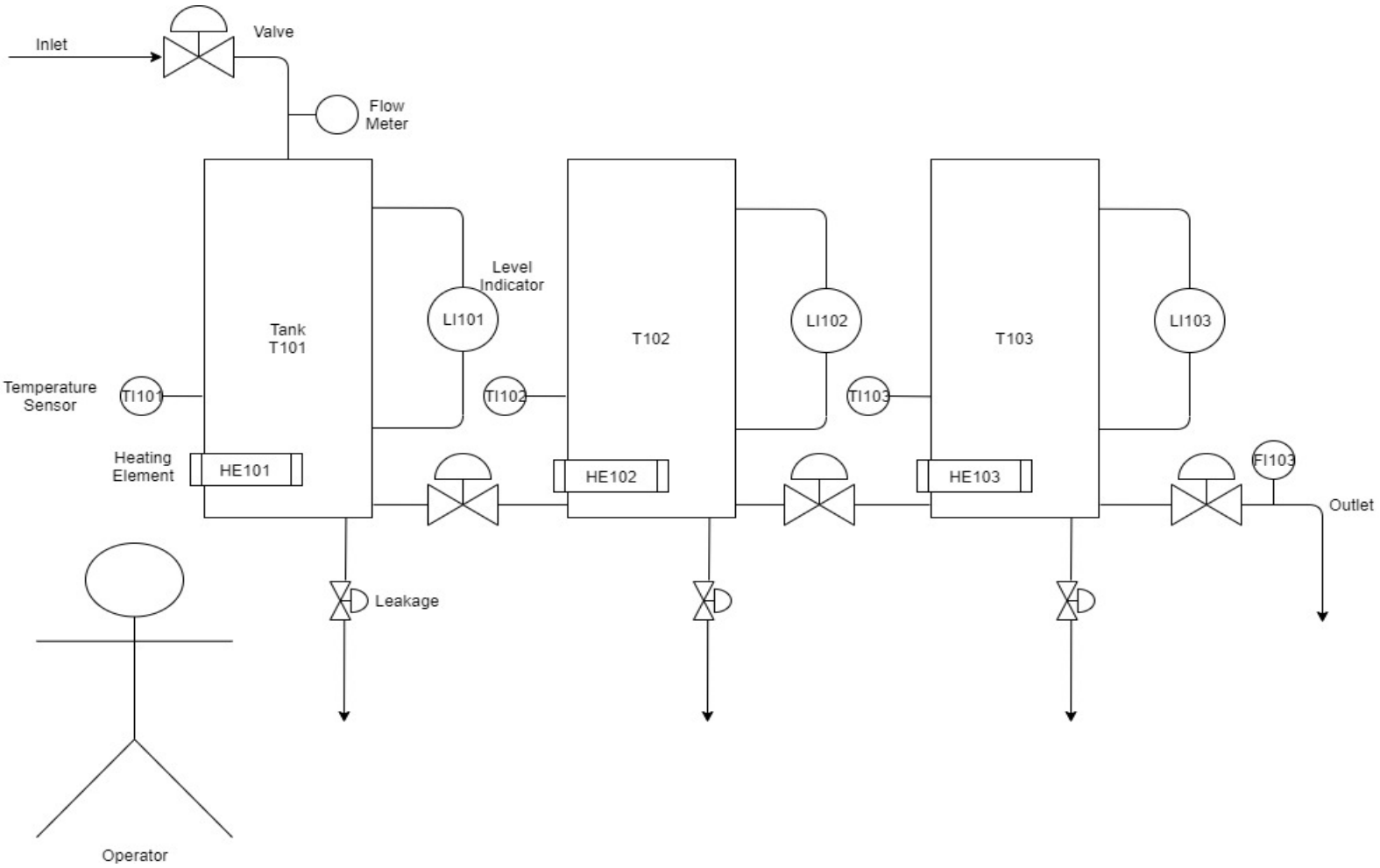


Fig 4. VR Model – Line Diagram

VR Development Environment- Unity 3D

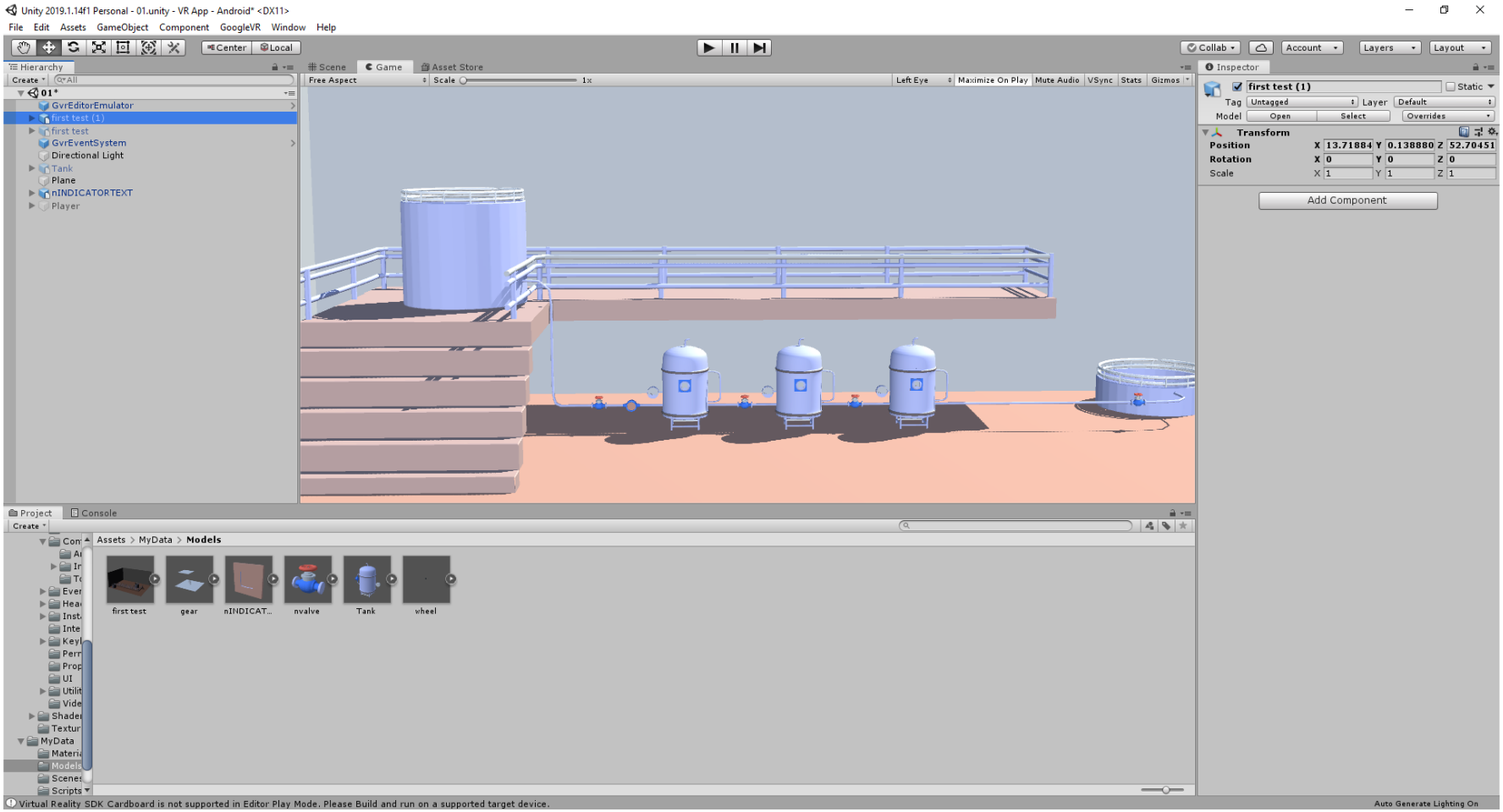


Fig 5. Unity 3D VR development tool

VR Model – Unity 3D

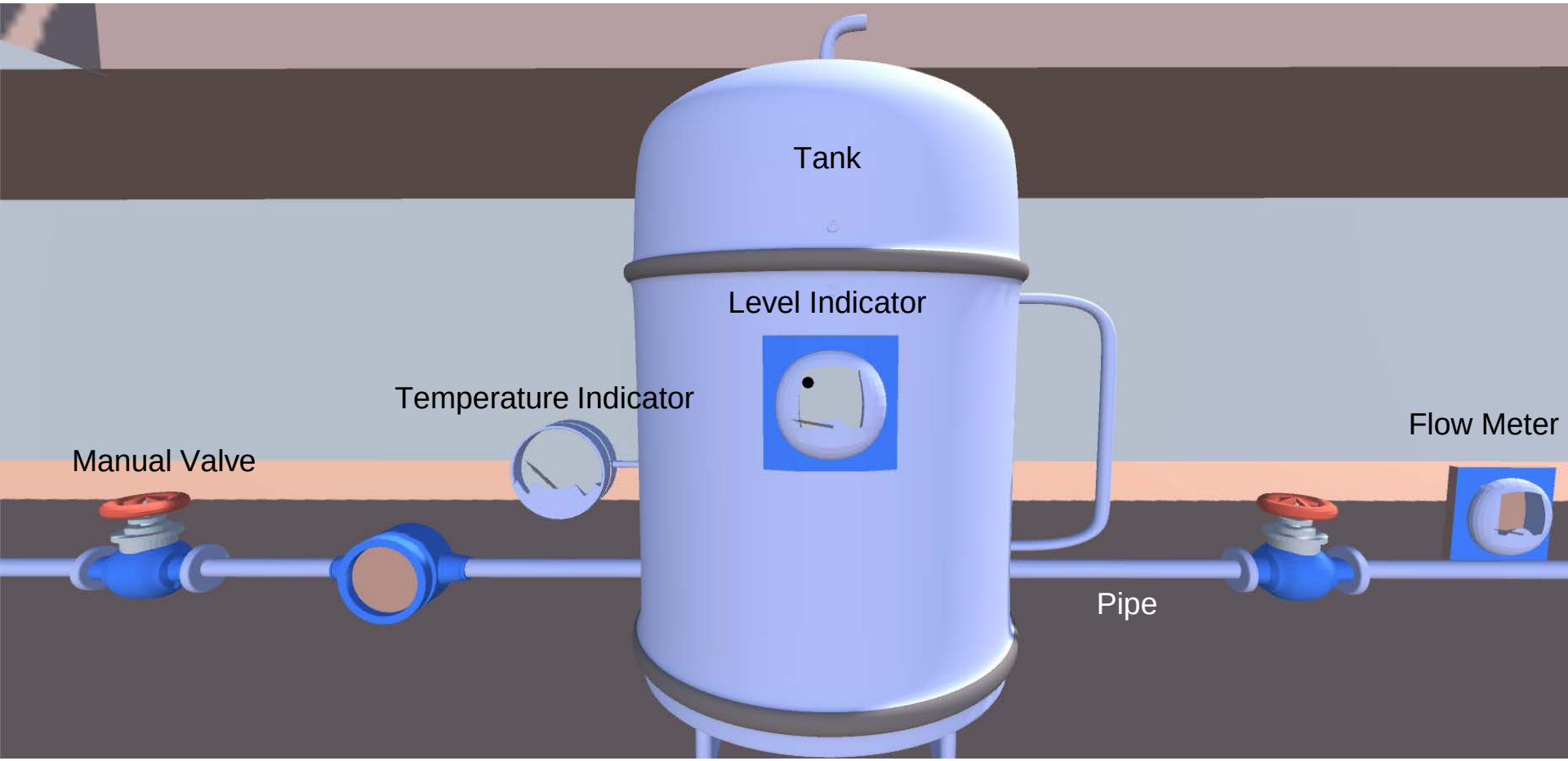


Fig 6. 3D Components of Resultant VR Model

VR Environment- 3 Tank Model

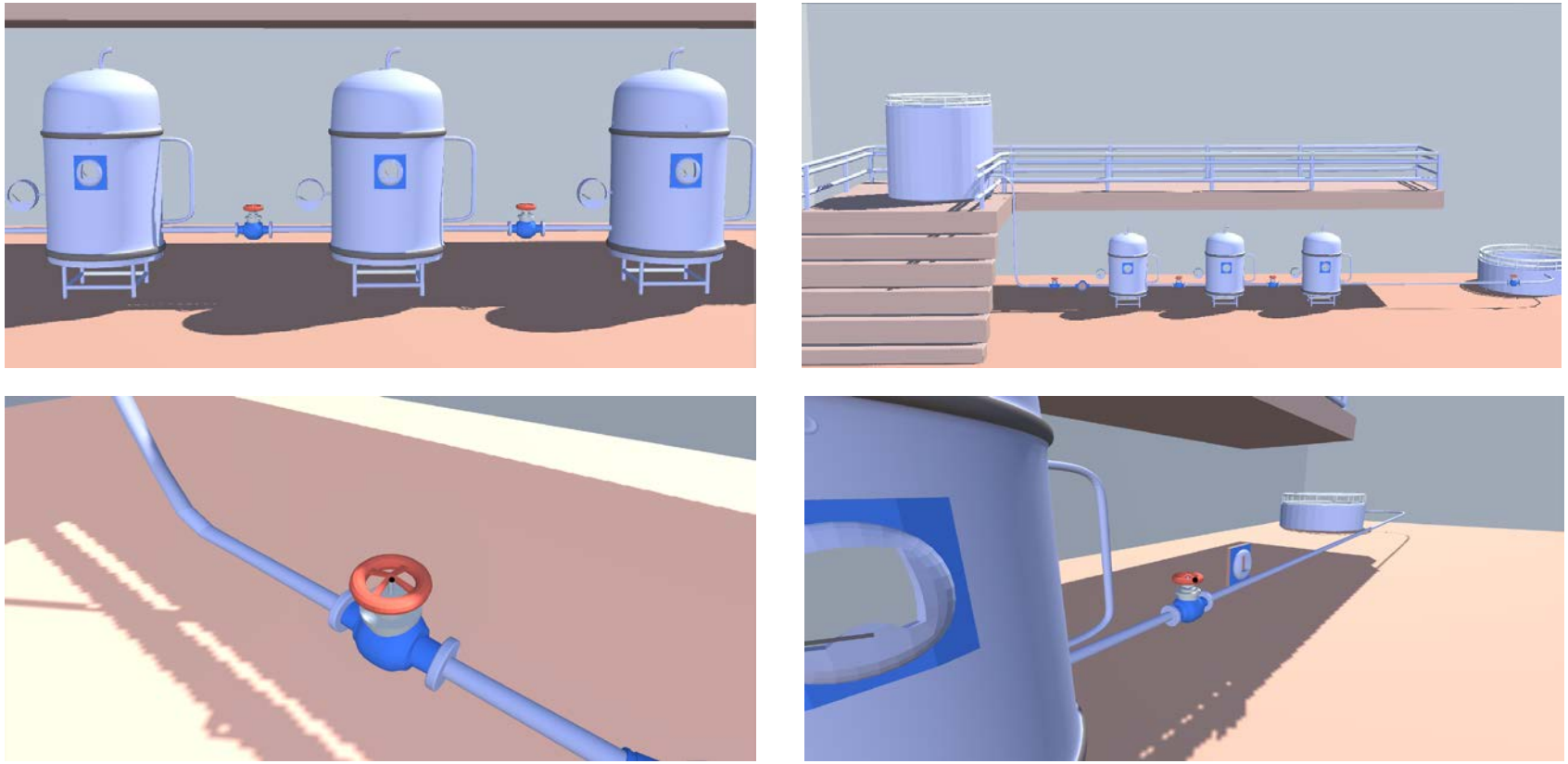


Fig 7. VR Environment Screens

CodeSys PLC & HMI: 3 Tank Model

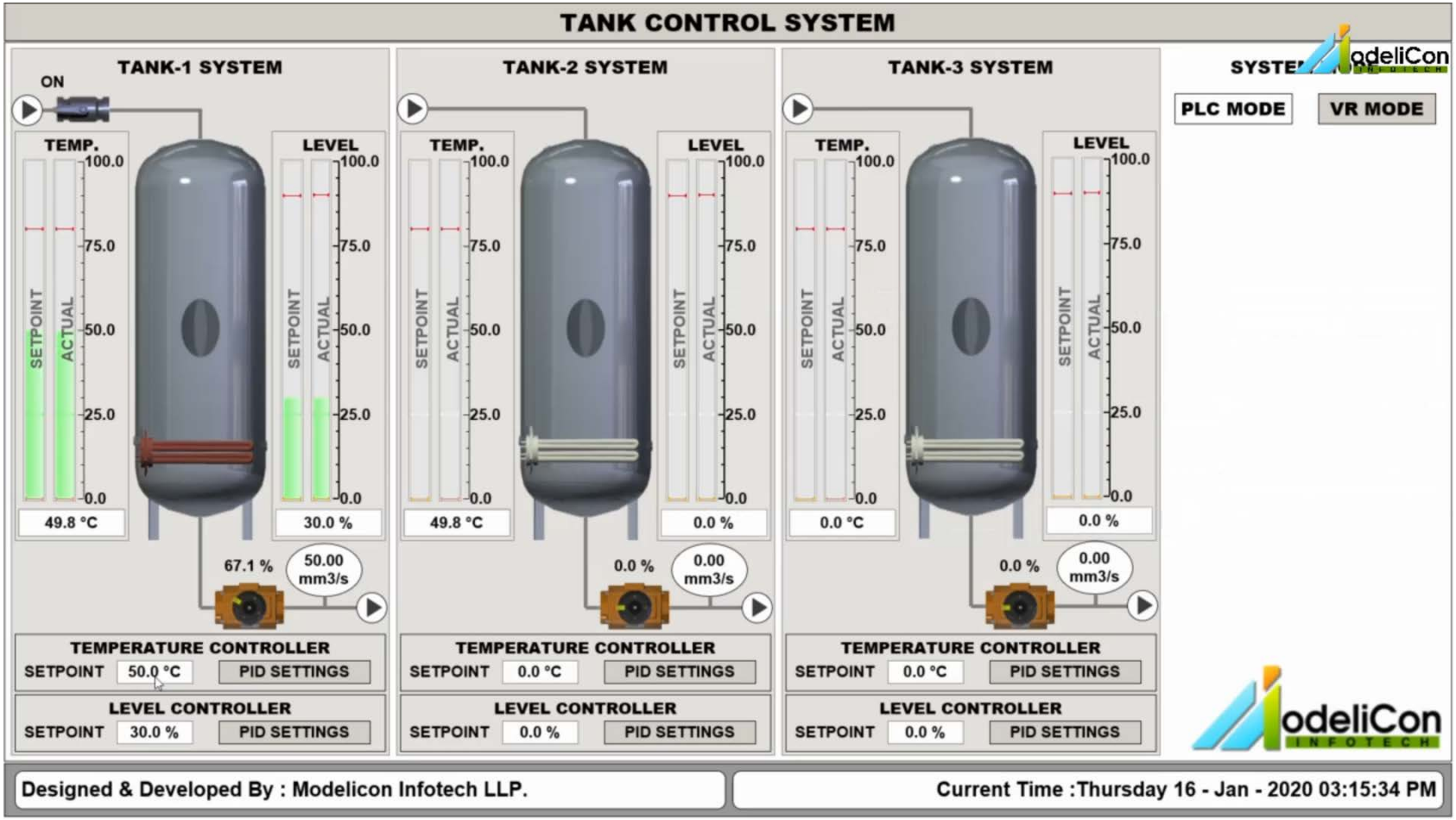


Fig 8. HMI screen in CodeSys

3. System Architecture

System Architecture

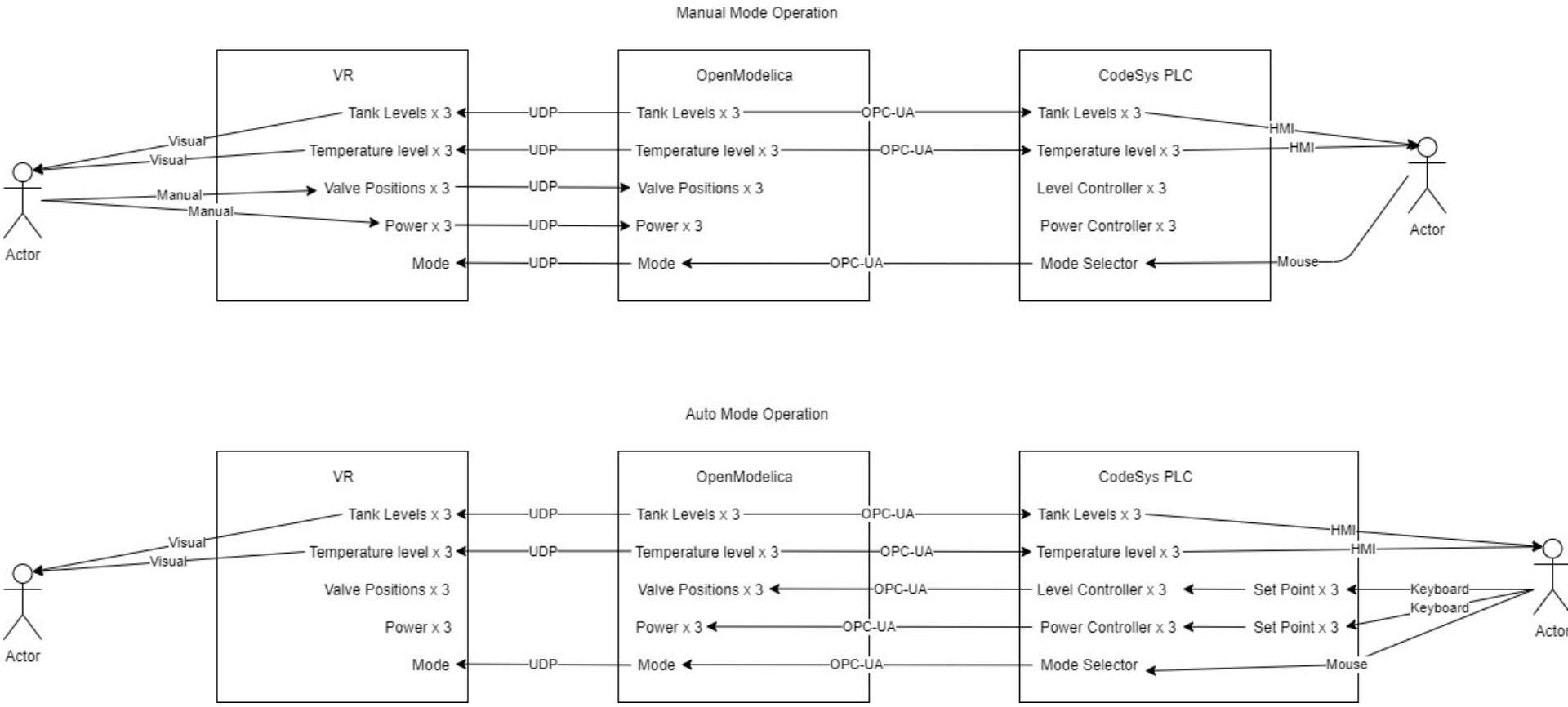
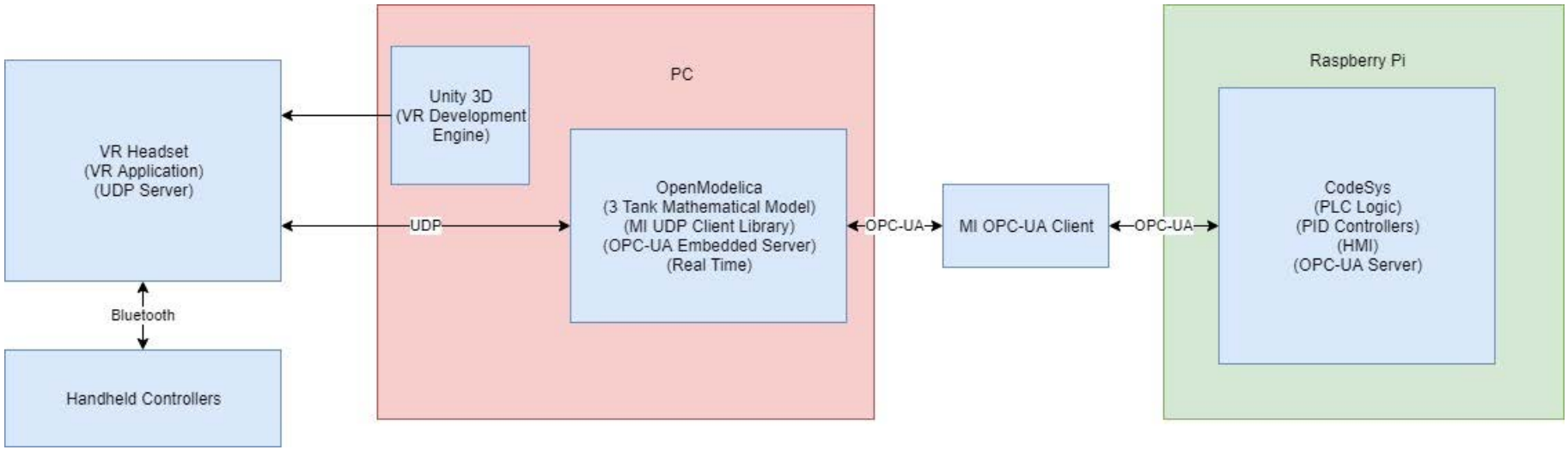


Fig 9. System Architecture

Data Exchange Architecture



Data flow diagram

4. Demonstration

One Tank Model- Demo

Results

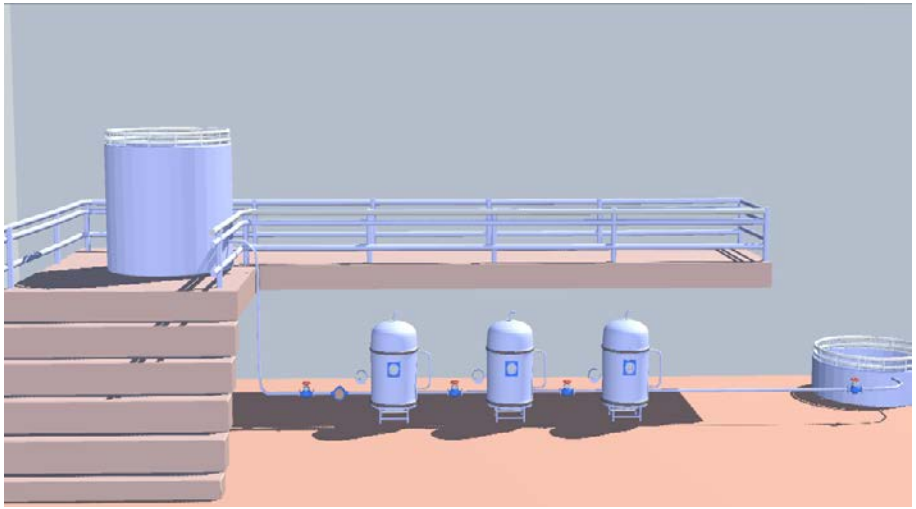


Fig 10. VR Screen

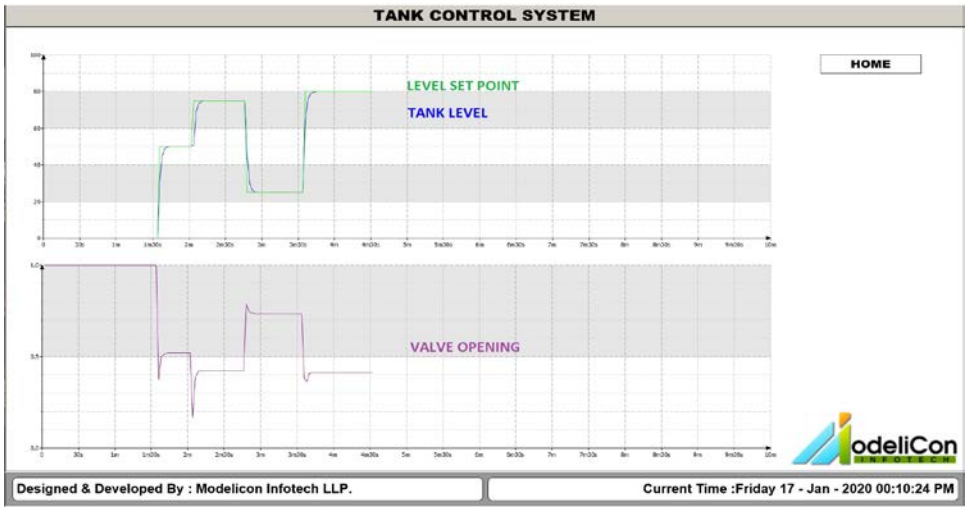


Fig 11. Real Time Graph and PID response

Fig 12. OM Plot, User's Input and Model's Response

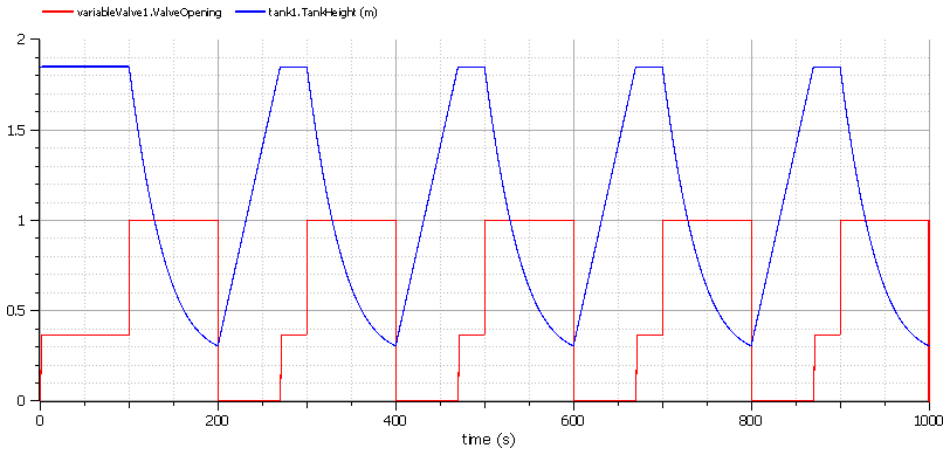


Fig 13. Model's behavior with pulse input

Future Scope

1. Development is being carried out in partnership with B.M.S. College of Engg., Bengaluru, India.
2. Two VR Models will be developed
   a. Interacting tanks model
   b. Steam turbine model
3. Students will be able to carry out various experiments using those models.
4. Solution can serve a great purpose both in academia as well as industry.

Thank You