InterchangeSE - A Real-Time Multiplayer Network 3D Visualization Framework to Simulate Driving Behavior and Interactions

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Presentation Outline

• Introduction
  • About Interchange Simulated Environment (SE) project

• InterchangeSE Architecture
  • Literature and evaluation criteria
  • Framework and implementation
  • Current status

• Next Steps
About InterchangeSE

• Study interactions among stakeholders in a partially connected-automated transportation system

• Integrate 3D Visualization, VR and AR technologies with communications between hardware and software components

• Multimodal simulated environments with scenarios spanning physical and virtual participants
About - Key Components

• Multiplayer interactions
• Decision perspectives from various stakeholders
• Variable levels of VR/AR immersion for stakeholders
• Fault tolerant modular design
• Interactions with real-world performance monitoring systems (PeMS)
• Wearable biosensor(s) to measure physiological responses induced by transportation system
About - Project Participants

• Turner-Fairbank Highway Research Center
• Virtual Reality Applications Center
• Real-Time Analytics of Transportation Data (REACTOR) Lab at In-Trans
• Augmented Reality wing of Banc3
InterchangeSE Architecture - Requirements

• APIs and applications in commercial, open-source and academic driving simulations were evaluated

• Criteria:
  • Software architecture
  • Network communication
  • Data processing and logging
  • Event definitions and updates
  • Authoring capabilities
Evaluated APIs and Software

- Traffic simulators
  - VISSIM
  - SUMO
  - MATSim
  - AIMSUN
  - Paramics
  - RoadTrafficSimulator
  - CARLA

- Stream data processing
  - VISSIM COM server
  - Unity Network server
  - Custom server
  - LVC COM server (ISU)

- Visualization
  - Unity3D
  - Other Commercial game engines
  - OpenSceneGraph/C++
InterchangeSE Architecture

- Traffic simulators
  - VISSIM
  - CARLA
  - Others

- Server receives and broadcasts state changes

- Unity3D based Multi-player scenario
  - Driving station 1
  - Driving station 2
  - Bike Station 1

- Pedestrians
- Construction workers
- First responders
- Other sims...
Networking Implementation

• Client-server architecture

• Photon Unity Networking API bridges the connection between traffic simulator (i.e., VISSIM) and the physical agent clients

• Photon server broadcasts traffic data from VISSIM to physical agents

• Framework will allow multiple physical agents to connect simultaneously, and can see each other regardless of VISSIM’s availability
VISSIM

- 64-bit, Windows OS, Commercial
- COM server based network communication
- Can handle 1000s of vehicles and pedestrians
- Algorithms are time driven and entity position based
- Authoring capabilities in-built
- Can simulate connected autonomous vehicles
- Supports multiple programming languages
- Came with a Unity project COM connected to VISSIM

Image courtesy: PTV VISSIM
CARLA

• Driving simulator intended for autonomous driving research

• Vision based
  • RGB Camera, Depth map, Semantic segmentation, ray-cast based lidar
  • Simulated or real data can be captured and processed from physical sensors

• Open source, on top of Unreal gaming engine

Image courtesy: http://carla.org/
Simulator Status

- Traffic simulators
  - VISSIM
  - CARLA
  - Others

- Server receives and broadcasts state changes

- Unity3D based Multi-player scenario
  - Bike Station 1
  - Driving station 1
  - Driving station 2

- Other sims:
  - Pedestrians
  - Construction workers
  - First responders
  - Other sims...
VISSIM ↔ Physical Agent Communication

- Physical agents implemented in Unity3D
  - Seen as ‘driving simulators’ within VISSIM
  - Once introduced within VISSIM, they are like any other traffic entities
- Upon execution, Unity3D app triggers opening an instance of VISSIM and automatically executes the scenario
  - VISSIM traffic is generated
  - Physical agents’ location and direction replicated
VISSIM Interaction with Physical Agents

- VISSIM traffic responds to physical agents’ position and direction, controlled by Unity3D

- VISSIM generated vehicles do not have any collision geometry, so physical agents can run into/through them
Bike Agent Setup

- Arduino board generates stationary bike riding signals
  - Translates to virtual bike motion in Unity3D
  - Natural handle bar turns changes bike direction
- Evaluated VirZoom hardware, but has restrictive subscription based licensing
- VR headset motion issues
Car Agent Setup

• Two Logitech G25 rigs setup in Unity
  • Physical gas and brake pedal, steering, Drive/Neutral/Reverse states implemented

• VISSIM traffic data relayed to Unity and displayed on a computer monitor
  • View can be extended up to four monitors depending on the graphics card capabilities in the PC/workstation

• Recently identified a suitable racing cockpit for use
Car Simulator Hardware Survey

CXC Motion Pro II ($50,000)
https://www.cxcsimulations.com/products/motion-pro/

Simtech Pro ($33,600)
https://simtechpro.com/en/

Virage VS500M
https://viragesimulation.com/vs500m-car-simulator-training-and-research/

GTR Racing Rig ($530)
https://gtrsimulator.com/

Next Level Racing cockpit ($800)
https://www.nextlevelracing.com/products/next-level-racing-gtultimate-v2/

Mophorn Cockpit ($270)

Rigs for use with custom software and Wheel/pedals

Next Level Racing kit with Motion platform ($5,300)

Logitech G920 or G25 ($300)
Banc3 AR Glasses

- X1 AR glasses provided to us
  - Not particularly convenient to use
- Requested for X2 version
- Need to evaluate its suitability

Image courtesy: Banc3 AR
Test Scenario
Next Steps

- Build VISSIM projects for the scenarios as recommended
- Implement CARLA as an additional mode within the framework
- Establish a work flow for authoring a scenario and importing into Unity
- Implement data logging capabilities for performance measurement and post-analysis
- Use stress sensors in conjunction with a live scenario to record TIM operator and driver stress levels
Thank you!

Questions?

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