

Model-Based Engineering of Digital Twins

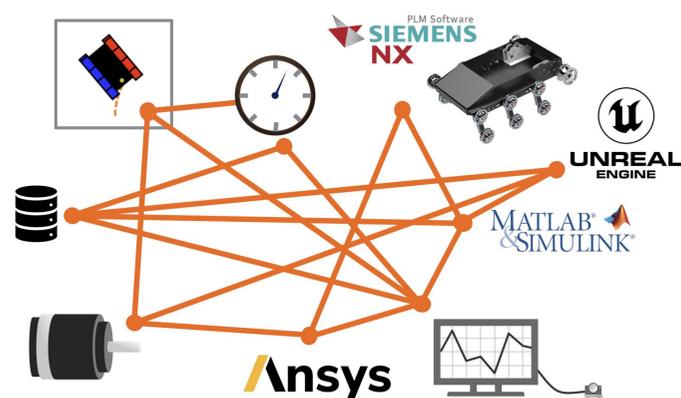
Supplemental Project — Focus Area 3 — Education and Outreach
Prepared for VIPR-GS Annual Program Review, February 2025

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Background

- Digital Twins (DTs) are generally described from a data-driven perspective, causing problems with connectivity, descriptiveness, and integration.
- Most DT systems become a rat's nest of hard-wired connections, duplicated information, and manually programmed interfaces.

The details of DTs are being explored by an undergraduate research group; this poster is a summary of some of their findings.



Traditional twins end up with a rat's nest of volatile, hardwired connections to siloed subsystems.

Fundamental Research Questions and Goals

- How can we represent DTs within an MBE framework?
- How can models be used in information exchange?

Undergraduate Research Group

- Models and infrastructure were created by undergraduate researchers participating in the **PLM Processes Creative Inquiry**, an elective research project directed by the PLM Center at Clemson University.
- Students meet weekly to learn principles of digital engineering, including PDM, CAx tools, MBSE, and project management. Microcredentialing from Siemens will be provided to next cohort of students as well.
- Students conduct experiments, program the robotics, and create models and sensor-networks over the course of the semester.



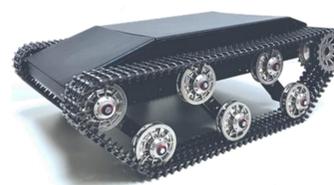
Students present at the 2024 Focus on Creative Inquiry (FoCI) Poster Forum.

Approach

- Group of undergraduate researchers created a digital twin for a tracked vehicle, with models representing geometry, motion, and power.
- Observational data is collected from sensors placed on the tracked vehicle.
- Models integrate through hard-wired scripts.

Definitions

- **Information:** the distinction between two or more data values.
- **State:** the information associated with an entity, often represented as variables.
- **Behavior:** the restriction of state due to interactions with another entity.
- **System:** a plurality of things whose interactions exhibit collective behaviors.
- **Model:** a virtual representation of the behaviors, and consequently interactions, of a system.
- **Digital Twin:** a virtual construct representing a physical system, used to observe, simulate, and influence the real system's state.



The tracked vehicle used as a digital twin; Left: An image of the physical twin, Right: A representation of the virtual space.

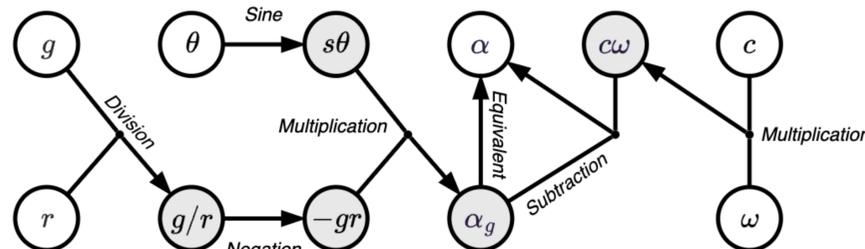
Key Findings and Results

Path for Creating Model-Based Digital Twins:

1. Deconstruct all objects into the representative information (variables).
2. Use models to show how information is connected.
 - Use APIs to connect specific software tools, visualizations, etc.
3. Build in data streams to provide inputs from real-world.

Conclusions

- True MBE is a dynamic connection of information through relationships described by the models.
- Object-oriented structures often relate
- Model-centric systems replace hard-wired connections.



A graph of the information in a digital twin system connected by edges representing models.

Next Steps

- Replace model integrations with state space hypergraph representation.
- Extend insights from robotic DT to full-scale ground vehicle.

