Augmented Reality in Power Systems

Path to Cyber Physical Systems

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Systems Engineering Domain Leader
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Shawn Hanegan

Expertise
> Systems Engineering
> Modeling and Simulation
> Technology Strategy
> Avionics, radar, training, software, cyber security

Work Experience
> Schneider Electric: January 2014 – Present
  - Systems Engineering Domain Leader
> MITRE Corporation
> Raytheon Company

Academic Experience
> Master of Engineering in Aeronautical Engineering (MIT)
> Bachelor of Science in Aeronautical Engineering (MIT)
What is Augmented Reality?
Augmented Reality

Quick Overview

- Reality: state of things as they actually exist (true environment, true sensor data)
- Virtual Reality: state of things as they might exist (simulated environment, simulated sensor data)
- Augmented Reality: state of things as they exist AND might exist (true environment, blended sensor data)
Schneider Electric and Parametric Technologies Corporation partnered to enhance the maintenance experience of a UPS

- Quick ID of problem device
- Visual step by step of how to replace battery
- Live status of device displayed on AR
- Maintenance done right first time
- Can improve safety
What are Cyber Physical Systems?
“Smart, connected products are transforming how companies design, manufacture, operate and service products, and ultimately, how they organize to create and capture value.”
Internet of Things

Quick Overview

Smart, connected products and other “Things” connected through an Internet-like infrastructure to a computing infrastructure, creating new forms of value.
Industry 4.0

We are now in the fourth Industrial Revolution

*Image Credit: Christoph Roser at AllAboutLean.com*
Cyber-Physical Systems

- Cyber-physical systems (CPS) are engineered systems that are built from, and depend upon, the seamless integration of digital and physical components
- Digital Components
  - Electrical and Mechanical Computer-Aided Design (CAD) models
  - Software/Firmware
  - Requirements and Test Documentation
- Physical Components
  - Motors
  - Structural Elements
  - Humans
Columbiad Experiment Series

Validation of Model Based Systems Engineering Processes
Two Core Technologies of Systems Engineering Domain

- A “**System**” is an integrated set of interacting elements that are organized to achieve one or more defined objectives.
- A “**Model**” is a representation of one or more structural or behavioral attributes of a real world or conceptual entity.

**Core Tech 1: “System Model”**
A representation of a specific system used to drive design, simulate performance, and conduct structural and behavioral analysis.

**Core Tech 2: “Model-Based System”**
A system that is designed, built, tested, and operated through a continuous, real-time link to its system model.

Construct the **System Model** and establish the link to symbiotic **Model-Based System**
Jules Vernes’ *Columbiad* 1865…
Columbiad History and Systems “V”

Columbiad I:
March 2015

- Stakeholder Reqts Definition
- Offer Requirements Definition
- System Requirements Definition
- System Architectural Design

Columbiad II:
December 2015

- Offer Model
- Implementation

Columbiad III:
March 2016

- Reuse Library
- Offer Acceptance
- Offer Validation
- System Verification
- System Integration

Columbiad IV:
August 2016

- Offer Requirements Definition
- System Requirements Definition
- System Architectural Design
- Implementation
- Reuse Library
- Offer Acceptance
- Offer Validation
- System Verification
- System Integration
Columbiad Prototype
Off the Grid Solar Panel Array

- Solar panels move to track the Sun and increase power generation
  - Can be easily deployed remotely without calibration
- For maintenance, solar panels can also be commanded in other orientations
  - Each individual panel can be set to a particular mode
  - Can lie flat for cleaning, vertical to drop debris
- Power is easily accessible directly from panels
- Digital representation allows viewing of status and control of array from any Internet device
Why is Columbiad a Cyber-Physical System?

Seamless Integration of the Digital and Physical

- For Columbiad, whatever happens in the Digital world also happens in the Physical world
  - Autonomous Mode: Physical Sun stimulates diodes and servos move to maximize energy
  - Manual Mode: Operator or Digital Sun send azimuth and elevation commands to servos
  - Both Modes: State of the Digital components is reflected in the Physical components
  - Both Modes: State of the Physical components is reflected in the Digital components

- This is a new way of thinking about products that must be considered in design
  - The digital versions of our products are just as important as the physical versions
Columbiad Augmented Reality

Each Solar Panel Module is IOT-enabled

- Instantaneous Power Sensor Data
- Cumulative Power Data
- Elevation Sensor Data
- Azimuth Sensor Data
Live Demo
Real World Application
1.3 billion people have no access to electricity
Schneider Electric is committed to tackle this challenge with the BipBop program: Business, Innovation & People at the Base of the Pyramid

Mobile medical or disaster recovery facilities sometimes do not have grid access
A portable, solar powered system can help with some basic needs, including cooling

Columbiad will provide an easily deployable, mobile cooling station
Future designs can incorporate battery technology for lighting, charging electronic devices, etc.

Augmented Reality allows for remote monitoring and maintenance
A command station can be set up to receive alerts concerning problematic devices, remotely address problems, or set up for maintenance
Potential Application- Zero Energy Air Conditioner

- 70% of Bangladeshis live without power
- Eco-Cooler was invented there to use waste products and wind to cool tin huts
- Wind enters through top part of soda bottles and is compressed at neck (ideal gas law)
- Up to 5 degrees Celsius cooling achieved
- Columbiad extends this principle by generating power that can be used to run a fan with electricity generated by solar panels
Conclusion
Conclusion

• Columbiad is a series of experiments used to validate Systems Engineering processes at Schneider Electric
• Prototype is a cyber physical system with two way digital-physical communication
• Greatly improves customer experience for a given product
  • Quick assessment of problems
  • Improved efficiency
  • Rapid and accurate maintenance
  • Can be extended to safety improvements
Questions
Tech Trends that Enable Cyber-Physical Systems

“A confluence of trends and technologies promises to reshape the way things are made”*

Improved data infrastructure
- i.e. Massive storage, computational power, wireless connectivity, internet of things

Advanced analytics and business-intelligence capabilities
- i.e. Natural language processing, machine learning, semantic web technologies

New forms of human-machine interaction
- e.g. Touch interfaces, hyper-custom dashboards, augmented-reality

Seamless transfer of digital instructions to the physical world
- e.g. Robotics, 3-D printing, CNC milling, etc

Vision - Cyber Physical System

- Solar panel controlled by a microprocessor

- Augmented reality display of real-time orientation and performance
  - Shows real-time physical orientation of solar panels
  - Access real-time and historical power data via Internet/Intranet
  - Calculate efficiency of panels (actual power given solar conditions) and alert to fault conditions

- Digital representation can control physical unit
  - Remotely control panel orientation
  - Maintenance mode where panel lies flat for cleaning
Columbiad IV Web View