Context Aware Software Stacks for Mobility

Composive.ai Overview

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Outline

• Background
  – AD software: System Design Approaches
  – Contextual AI & Explainable AI
• Context & Context Awareness for AD
• Composive.ai: Goals
• Model Driven Adaptive Software Stacks
• Roadmap
Background

- AD software performs well in a specific context.
  - Dependent on training data and models
  - Unexplainable bias.
  - Underperforms in corner cases.
- The AI Next Campaign (DARPA) is announced:
  - A third wave that brings forth machines that understand and reason in context.

Contextual AI & Explainable AI

PILLARS OF CONTEXTUAL A.I.

**Intelligible**
- Able to explain what it knows, how it knows, and what it’s doing.

**Adaptive**
- Able to meet user’s expectations in different environments.

**Customizable**
- Able to be fully controlled by the user.

**Context-Aware**
- Able to perceive at the same level as a human does.

**AI System**
- We are entering a new age of AI applications
- Machine learning is the core technology
- Machine learning models are opaque, non-intuitive, and difficult for people to understand

**DoD and non-DoD Applications**
- Transportation
- Security
- Medicine
- Finance
- Legal
- Military

- Why did you do that?
- Why not something else?
- When do you succeed?
- When do you fail?
- When can I trust you?
- How do I correct an error?

**User**

Relation to the structure of the models of the system

*Contextual AI: The Next Frontier of Artificial Intelligence, Oliver Brdiczka*

*Explainable Artificial Intelligence (XAI), Dr. Matt Turek*
Context Variation Example

- Humans are pretty successful at understanding the context changes
- The design and capabilities (sensing, detecting, tracking, planning etc.) of AD software should match.

Urban Driving (Organized vs Unorganized)  Parking Lot Driving (Indoor vs Outdoor)
Context & Context Awareness for AD

- Sensory
  - Distance (Lidar)
  - Speed (Radar)
  - Object detection (Camera, image processing, ML)
  - Orientation (SLAM, 3D Maps)
- Behavior
  - Driver, Pedestrians, Other Drivers
- Environment
  - Traffic signs (Object detection, image processing)
- Mission
  - Purpose (park, cruise ..)
  - Destination
  - Planning
Composiv.ai Goals

• Change the **existing** state towards the **desired** state (i.e. from urban driving context to parking context).

• Ability to abstract **contextual** knowledge for AD.

• Ability to **modify** runtime code (vs. code-first black-box proprietary systems).
ROS2 System

ROS graph is a network
- ROS 2 elements (executables) and connections processing data together

[Diagram showing ROS nodes and connections]


Model Based Robotics in ROS2 ecosystem

RobMoSys:
- Enables the *composition* of robotics applications with managed, assured, and maintained system-level properties via *model-driven* techniques.

MROS:
- *The objective of MROS is to leverage the RobMoSys model-based approach at runtime*, to provide a solution for ROS2 systems, based on architectural self-adaptation driven *by ontology reasoning* on the architecture models.
Model Driven Context Aware Stacks

- **Existing Systems**
  - Reverse engineer
  - Metamodel Driven

- **Initial Model (View)**
  - Conforms to

- **Metamodel (low-level Viewpoint)**
  - Represents

- **Metamodel (Function-Level Viewpoint)**
  - Conforms to
  - Metamodel Driven

- **Initial Model (View)**
  - Represented

- **Adapted Model (View)**
  - Adapt
  - Deploy
  - Runtime Platform
Model-driven Approach with open-source AD stack
Modeling Existing AD Framework (Autoware)

Partial Autoware Node-Graph Diagram

ROS2 Based AD Model Concept

Model for a ROS2 runtime (i.e. Autoware)

Nodes (Processes)
- clustering
- lidar
- Image detector
- camera
- Object fusion
- point cloud filter
- point localizer
- Semantic mapper
- potential mapper
- route planner
- lane planner
- Vehicle pose
- lattice planner
- filtered point cloud
- waypoint follower

System / SubSystem

Topics
- Point Cloud
- objects
- Image objects
- Point objects
- filtered point cloud
- velocity
- Current velocity
- Sem. map
- potential. map
- ADAS Map Info
- pose
- waypoint

Entities (events/data)
- object
- ADAS Map Info
- map
- Point cloud
- Image
- pose
- velocity
- Vehicle control

Associations (pub/sub, req/reply)
- Node
  - Topic (pub)
  - Topic (sub)
  - Node

context
Composiv.ai Components

SDKs for Stack and Component Development

LiveUI
UI Stacks
Client Devices

LiveFlow
Flow Stacks
Cloud (MW) Platforms

LiveStream
Edge Stacks
Edge Devices

Context Awareness

Algorithm & Model Development

Feature Engineering

Model Driven Stacks

Stack (App & Service) Repositories

Stack Lifecycle and Trust Management

Sensor Ocean

Context Awareness

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Roadmap

• Architectural Definitions & Requirements Analysis (09/2021)
  – Autonomous Vehicles
  – Autonomous Driving Software Stacks

• CASSM v1 (01-03/2022)
  – Models and algorithms

• CASSM Edge Runtime Platform v1 (01-03/2022)
  – LiveStreams (Composive.ai)
  – ROS2/DDS

• Micro user interfaces and flows SDK v1 (01-03/2022)
  – LiveUI (Composive.ai)
  – LiveFlow (Composive.ai)

• Case Studies
  – Case Study I: Modeling studies based on open-source modular AD software stack.
  – Case Study II: Testing on a 1/10th scale RC car conforming to f1ftenth.org specs
Thank you for listening and for your attention.

We’d be glad to answer any questions...

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