CONCEPT QUALITY REPLY

THESIS PROJECT PROPOSALS

YEAR 2026/2027

This document presents a curated set of thesis project proposals for the academic year 2026/2027, developed by Concept Quality Reply. The initiatives outlined aim to address current challenges in Quality Assurance, validation methodologies, and advanced testing frameworks across multiple domains, including automotive, robotics, industrial systems, and artificial intelligence.

Each proposal is designed to combine theoretical knowledge with hands-on experimentation, leveraging cutting-edge technologies such as simulation environments, digital twins, machine learning, and robotic platforms. The objective is to provide MSc students with the opportunity to contribute to innovative, real-world projects while developing strong technical and analytical skills.

Through collaboration with multidisciplinary teams within Reply's innovation ecosystem, particularly in the Area42 lab, students will engage in end-to-end project activities ranging from design and implementation to validation and performance evaluation. This document serves as both an overview of available opportunities and a guide to the competencies and technologies involved in each project.

GET TO KNOW THE COMPANY

Concept Quality Reply is the Company of the Reply Group that leads product Quality Assurance and implementation of validation solutions. It covers a huge stack of different market and technology areas among the entire Reply service offer.

Our mission is to evaluate the Quality Assurance of products and services ranging from the Finance area to the Telecommunications one, passing from IoT devices, Automotive and Humanoid robots projects. Concept Quality integrates QA skills in Hardware and Software with those of Test Automation and Digital Customer Experience, across all projects: everything, in one single Company!

On a technical and technological level, our team has an eye toward the future: in fact, Agile and DevOps approaches are increasingly applied within us, combining the classic Quality Assurance methodologies with the most modern techniques for implementing automatic tests with particular attention to scenarios where Artificial Intelligence, Machine Learning, Data Analysis and Processing, Computer Vision and Robotics are required.

INTERNSHIP CONDITIONS

- The MSc student will receive from the Company a refund of 500 euro/month (full-time) together with lunch vouchers.
- The MSc student will be part of a Team working in Area42, in the Reply building in Turin (Via Nizza 250)
- Other logistics agreements will be evaluated accordingly with the chosen proposal

[VC_1] INTEGRATING HARDWARE-IN-THE-LOOP (HIL) SOLUTIONS IN VIRTUAL COMMISSIONING FOR INDUSTRIAL FACILITIES

Context

The industry is evolving towards complex systems that support engineers in the development and validation of entire industrial facilities. This project aims to transition from a simulation-only approach to a mixed approach where simulation serves early development stages, integrating Hardware-in-the-Loop (HiL) solutions. The focus will be on creating a demo case for an industrial facility dedicated to anomaly detection through camera systems.

Project description

This project will develop a test bench that includes a small conveyor system, a camera-based detection system using Raspberry Pi, an industrial controller (PLC), and a digital twin created using Omniverse. The HiL setup will enable bidirectional testing, and validation flows between the digital twin and its physical counterpart. This integration will allow for real-time anomaly detection and validation of the camera system's performance in a controlled environment, facilitating the transition to more complex industrial systems.

Objectives

- Design and implement a Hardware-in-the-Loop test bench that integrates a small conveyor, a camera-based detection system, and an industrial controller.
- Develop a digital twin of the test bench using Omniverse to simulate and visualize the system's operation.
- Establish bidirectional communication between the physical test bench and the digital twin to enable real-time testing and validation.
- Conduct experiments to evaluate the effectiveness of the anomaly detection system and refine the integration process based on findings.

Prerequisites

- NVIDIA Isaac Sim
- Computer Networking and Internet Protocols
- Python Programming
- Nice to have: Basic Electronics Knowledge

Skills acquired

- Proficiency in designing and implementing Hardware-in-the-Loop systems.
- Enhanced skills in developing and utilizing digital twins for industrial applications.
- Experience in real-time data acquisition and processing from physical and virtual systems.
- Knowledge of anomaly detection methodologies using camera-based systems.

Technological stack

Omniverse, Raspberry Pi, Arduino Opta Pro, Mini conveyor, Cameras, Python, C/C++

[AD_1] DEVELOPMENT OF A MODULAR TESTING PLATFORM FOR ADAS PARKING SENSOR AND SURROUND VIEW SYSTEMS

Context

Integration testing is a challenging aspect of validating Advanced Driver-Assistance Systems (ADAS) perception stacks, often requiring advanced vehicle prototypes, significant resources, and quick responses. Automakers face difficulties in finding modular solutions that ensure test repeatability, precision, and automation. This project aims to replicate a client project in a simplified demo version to be showcased in the Area42 lab, the innovation lab of Reply.

Project description

The project will focus on creating a modular plug-and-play testing solution for parking sensor systems based on proximity sensors and surround view camera systems. The system will feature a mechanical structure that supports various car line geometries and a robotic platform designed for scalable, scenario-based testing with diverse obstacles. Key features will include the design and manufacturing of carts and obstacles, parking sensor validation, and the implementation of a Capture/TAP/Replay mode for image-in-the-loop testing.

Objectives

- Design and manufacture a mechanical structure that accommodates various car geometries for the testing platform.
- Develop a robotic platform capable of carrying different types of obstacle mocks to stimulate the parking sensors and surround view systems.
- Implement the Capture/TAP/Replay mode for effective testing of the surround view camera and parking sensor systems.
- Establish centralized control for multi-robot trajectories fuzzing to ensure scenario-based testing and automation.
- Create virtual ECU models to simulate the vehicle's electronic control unit during testing

Prerequisites

- Computer Networking and Internet Protocols
- Python and C++ Programming
- Nice to have: ROS2, Computer Vision, 3D Printing

Skills acquired

- Proficiency in designing modular testing platforms for automotive applications.
- Experience in scenario-based testing and automation techniques.
- Skills in integrating various sensor systems and validating their performance.
- Knowledge of virtual ECU modeling and image processing for ADAS validation

Technological stack

Raspberry Pi, Arduino, 3D printers, FreeCAD, Cameras, Ultrasonic sensors, ToF sensor, Python, C/C++

[AUV_1] AUTONOMOUS UNDERWATER TESTING AND SYNTHETIC DATA GENERATION FRAMEWORK WITH OCEANSIM

Context

The development and validation of Autonomous Underwater Vehicles (AUVs) require robust testing methodologies that incorporate various scenarios and environmental conditions. This project focuses on generating synthetic data from diverse underwater scenarios to support the testing and validation of the perception stack of AUV. By leveraging NVIDIA Isaac Sim and the OceanSim framework, the project aims to create a comprehensive approach to evaluate the performance of AUVs in realistic conditions.

Project description

This project will develop a framework for generating synthetic sensor data from a variety of underwater scenarios, including different obstacle configurations and environmental conditions. The focus will be on simulating sensors such as sonar, cameras, and other detection systems to produce realistic data that can be used for testing AUV navigation and control algorithms. The project will utilize NVIDIA's advanced simulation capabilities to create scenarios that reflect real-world challenges, enabling the effective validation of AUV systems in a controlled environment.

Objetives

- Design and implement a variety of underwater scenarios to generate synthetic data for AUV sensor systems.
- Simulate different types of sensors, including sonar and cameras, to create realistic datasets for testing and validation.
- Develop methodologies for evaluating AUV performance based on the synthetic data generated from these scenarios.
- Create a framework for scenario-based testing that allows for rapid iteration and refinement of AUV algorithms.
- Validate the effectiveness of the synthetic data in improving the reliability and accuracy of AUV navigation and control systems.

Prerequisites

- NVIDIA Isaac Sim
- Python Programming
- 3D Computer Graphics and Rendering
- Nice to have: Computer Vision, Fluid Dynamics knowledge

Skills acquired

- Proficiency in generating and utilizing synthetic data for testing and validation of underwater robotics.
- Experience in simulating and integrating various sensor systems for mechatronic systems.
- Skills in developing scenario-based testing frameworks.
- Knowledge of data evaluation techniques to assess the effectiveness of AUV navigation and control systems in realistic environments.

Technological stack

NVIDIA Isaac Sim, OceanSim, Python, C/C++

[OB_1] OBSERVABILITY-BASED TESTING FRAMEWORK FOR HUMANOID ROBOT MANIPULATION POLICIES

Context

The development of manipulation policies for humanoid robots requires rigorous testing and validation to ensure their effectiveness in real-world applications. This project aims to establish a testing framework based on observability methods to evaluate manipulation policies across various humanoid robots available in the Area42 lab, including the 2xUnitreeG1 with different end effectors, the Fourier GR2, and the upcoming Agibot A2 Ultra. The existing pipeline for developing manipulation policies, which involves various teleoperation devices and AI architectures, will serve as the foundation for this framework.

Project description

This project will focus on creating a comprehensive testing and validation framework that leverages observability methods to assess the performance of humanoid robot manipulation policies. By utilizing the existing pipeline, which includes the Lerobot framework and policy architectures like ACT and Gr00t, the project will develop a structured approach to test and validate the manipulation capabilities of humanoid robots. The framework will allow for systematic evaluation of the robots' actions, ensuring that the manipulation policies are robust and adaptable to different scenarios.

Objectives

- Develop a testing framework based on observability methods to evaluate humanoid robot manipulation policies.
- Integrate various humanoid robots in the Area42 lab into the testing framework for comprehensive evaluation.
- Utilize existing teleoperation devices and AI architectures to facilitate the development of manipulation policies.
- Monitor key metrics to assess the effectiveness and adaptability of manipulation policies in different scenarios.
- Analyze results to refine manipulation policies and improve the overall performance of humanoid robots

Prerequisites

- Knowledge of Robotics (e.g., kinematics, control)
- Python Programming
- Machine Learning and Deep Learning

Skills acquired

- Proficiency in developing testing frameworks for humanoid robot manipulation policies.
- Experience in applying observability methods to assess robotic performance.
- Skills in integrating various robotic systems and teleoperation devices for policy development.
- Knowledge of analyzing and refining manipulation policies based on systematic testing results.

Technological stack

Humanoids Robots, IsaacSim, Ros2, LeRobot, FreeCAD, 3D printers, Cameras, Python, Pytorch, C/C++

[PH_1] AUTONOMOUS END-TO-END HMI TESTING FRAMEWORK USING ROBOTIC FACILITIES AND NVIDIA'S CAP-X

Context

In the automotive industry, effective Human-Machine Interface (HMI) testing is crucial for ensuring user safety and system reliability. This project aims to develop an autonomous end-to-end (E2E) testing framework that utilizes robotic facilities, such as robotic arms equipped with cameras, in conjunction with NVIDIA's CAP-X (Code as a Policy) approach. The goal is to create a system that adapts to changes in the system under test throughout the development lifecycle by autonomously understanding the context.

Project description

This project will establish a testing framework that integrates robotic arms and cameras to perform autonomous E2E testing of HMI systems in vehicles and test benches. By employing physical AI, the framework will simulate real-world interactions and adapt to varying conditions during testing. The CAP-X approach will enable robotic systems to interpret real-time data and modify their behavior, enhancing adaptability and performance in dynamic environments.

Objectives

- Develop an autonomous E2E testing framework for HMI systems using robotic facilities.
- Integrate robotic arms with cameras to simulate real-world scenarios and interactions.
- Implement the CAP-X approach to enable context-aware adaptations during testing.
- Validate the effectiveness of the framework in ensuring HMI reliability and user safety.

Prerequisites

- Knowledge of Robotics (e.g., kinematics, control)
- Python Programming
- Agentic Programming
- Computer Vision

Skills acquired

- Proficiency in developing autonomous testing frameworks for HMI systems.
- Experience in integrating robotic facilities for real-world scenario simulation.
- Skills in applying the CAP-X approach for adaptive robotic behavior.
- Knowledge of validating HMI systems in dynamic testing environments.

Technological stack

UFactory X-Arm robot, FreeCAD, 3D printers, Cameras, Python, C/C++, Java, Javascript, CAP-X, LLM, Vector, Test Automation Framework, Android Debug Bridge, CAN

[AG_1] DIGITAL TWIN DEVELOPMENT FOR VIRTUAL SCENARIOS GENERATION AND IMAGE-IN-THE-LOOP TESTING OF AGRICULTURAL ROBOT'S PERCEPTION STACK

Context

As agriculture increasingly adopts automation, the need for accurate and reliable perception systems in autonomous robots becomes critical. This project focuses on creating a digital twin of various plant species and plantations, utilizing advanced 3D reconstruction techniques powered by Generative AI. The goal is to enhance the perception stack of agricultural robots through a robust image-in-the-loop testing framework.

Project description

The project will involve the development of a digital twin that accurately represents different plant species and their environments. Utilizing Generative AI, the digital twin will be constructed through 3D reconstruction techniques that transform real-world field data into a virtual environment. The digital twin will serve as a testing ground for the perception stack of autonomous agricultural robots, allowing for image-in-the-loop simulations that facilitate the evaluation of perception algorithms under varied conditions.

Objectives

- To create a detailed digital twin of selected plant species and related varieties (diseases, seasonality.)
- To implement advanced 3D reconstruction techniques using field data.
- To enhance perception algorithms through data augmentation methods utilizing Generative AI.
- To run validation sessions for the perception stack of autonomous robots using an image-in-the-loop approach.

Prerequisites

- Basic understanding of robotics and automation in agriculture.
- Familiarity with 3D modeling and rendering.
- Familiarity with a Game Engine.
- Knowledge of Generative AI and data augmentation methods.
- Proficiency in programming languages relevant to simulation and AI (e.g., Python, C++).

Skills acquired

- Proficiency in 3D reconstruction and modeling techniques.
- Experience with Generative AI and its applications in data augmentation.
- Understanding of perception algorithms and their testing methodologies.
- Skills in using simulation platforms for autonomous systems.

Technological stack

Unreal Engine, Blender, Omniverse, Cosmos, Pytorch, HuggingFace, Python, C/C++

[FR_1] EXPLORING GENERATIVE AI FOR CONTROLLABLE SYNTHETIC DATA GENERATION IN COMPUTER VISION SYSTEMS VALIDATION

Context

The increasing integration of advanced technologies in various industries necessitates robust validation methods for computer vision systems. A recent initiative aims to leverage generative AI to create a controllable simulator that can enhance the validation of face recognition systems. This approach addresses challenges such as environmental lighting variability and changes in user appearance, which are critical for ensuring the accuracy and reliability of biometric systems.

Project description

This project will explore the use of generative AI as a controllable simulator for validating computer vision systems, with a particular focus on face recognition technologies. The research aims to evaluate the effectiveness of generative models by examining various aspects such as semantic fidelity, which includes identity and scene coherence; geometric fidelity, focusing on pose and multi-view consistency; and photometric fidelity, which analyzes lighting and lens effects. Additionally, the project will assess physical fidelity through the control of camera parameters, ground-truth reliability by measuring the accuracy of measurements, and dataset quality by emphasizing diversity and scalability.

Objectives

- To evaluate the effectiveness of genAI in creating controllable synthetic data for computer vision validation.
- To establish a comprehensive evaluation framework based on the proposed taxonomy.
- To generate a dataset that meets requirements for effective validation of face recognition systems.
- To explore potential applications of the findings in other industries, including automotive and beyond.

Prerequisites

- Familiarity with computer vision principles and biometric systems.
- Understanding of generative AI models and their applications.
- Experience in data collection and analysis methodologies.
- Proficiency in programming languages relevant to AI and data processing (e.g., Python).

Skills acquired

- Expertise in generative AI and its applications in synthetic data generation.
- Proficiency in evaluating and validating computer vision systems.
- Understanding of dataset quality metrics and their implications for AI training.
- Skills in cross-industry application of AI technologies.

Technological stack

Image generator models, Python

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