# General Descriptions

* Ethical Framework Integration: Incorporating ethical frameworks into the software synthesis process ensures that the robots' actions align with moral principles and societal norms. i.e. fair distribution of resources, prioritizing human safety, and respecting privacy.
* The software performs **behavioral analysis** of individual robots within the system to understand their capabilities, limitations, and ethical decision-making processes.
* continuously improve their ethical decision-making based on feedback from interactions and outcomes by **learning and adaptation**.
* **Effective communication** between robots is crucial for coordinating ethically to resolve conflicts in a manner consistent with ethical principles.
* The software synthesizes algorithms for **task allocation and scheduling** that take into account not only efficiency and performance metrics but also ethical considerations such as **fairness** and **equity** among the robots.
* ethical conflict resolution.
* **Human-Robot Interaction**: While the goal is to automate as much as possible, the software also considers human input and intervention when necessary.
* **Ensemble-based software architecture** is a design approach that involves creating complex software systems by combining multiple, often diverse, components or modules into a cohesive and integrated whole. The term "ensemble" in this context refers to a group of elements or components working together harmoniously. Examples of ensemble-based architectures include service-oriented architecture (SOA), microservices architecture, and some approaches to the Internet of Things (IoT) where devices and services from various manufacturers and domains need to work together seamlessly.

# RoboChor: Robot Choreography

The project requires experience on:

## methodologies and languages to enable domain experts to specify missions for multi-robot systems.

## suitable assignment of robots to tasks.

## automated coordination of robots to avoid (emergent) behaviors that are undesired while guaranteeing ethics.

# Multi-Robots Environment

A multi-robot environment refers to a setting or scenario in which multiple robots, often autonomous or semi-autonomous, coexist and interact within the same physical or virtual space to accomplish tasks or objectives. These robots can be of various types, including ground-based robots, aerial drones, underwater vehicles, or even virtual agents in simulated environments.

# Service Robots

Service robots are robots designed to perform tasks and provide services to humans, often in various domains or industries.

## Key characteristics of a multi-robot environment include:

### Multiple Agents:

The environment involves two or more robots, each with its own sensors, actuators, and decision-making capabilities. These robots can operate independently or collaborate with each other to achieve common goals.

### Coordination:

Coordination mechanisms are essential in multi-robot environments to ensure that the robots work together efficiently and avoid conflicts. Coordination can involve communication, task allocation, path planning, and synchronization.

### Collaboration:

Collaboration among robots can take various forms, such as sharing information, sharing tasks, or working together on complex missions. Effective collaboration can lead to improved efficiency and the ability to tackle more challenging tasks.

### Diversity:

Robots in a multi-robot environment can vary in terms of their physical characteristics, capabilities, and roles. For example, a multi-robot team might include drones for aerial surveillance, ground robots for mapping, and underwater robots for inspection.

### Resource Sharing:

In some cases, robots in a multi-robot environment may share resources, such as sensor data, maps, or computing resources, to enhance their collective capabilities.

### Scalability:

Multi-robot environments can scale to accommodate a varying number of robots, making them suitable for applications ranging from small-scale tasks to large-scale operations.

# Examples

### Healthcare

Service robots in healthcare can assist with tasks such as patient care, medication delivery, and even surgery.

### Hospitality and Tourism

Robots in this domain can be used in hotels, restaurants, and tourist attractions for tasks like room service, concierge services, and providing information to visitors.

### Retail

Service robots can assist customers in stores, help with inventory management, and even perform tasks like stocking shelves.

### Agriculture

Robots are used in agriculture for tasks like harvesting crops, planting, and monitoring the health of plants and livestock.

### Education

Some service robots are designed for educational purposes, helping students learn and providing educational support.

### Cleaning and Maintenance

Robots can be used for cleaning tasks in homes, offices, and public spaces, as well as for maintenance and inspection in industrial settings.

### Security and Surveillance

Robots can patrol areas, monitor security threats, and provide surveillance in various environments.

### Multi-Robot Wildlife Conservation

Description: Multi-robot systems are employed in wildlife conservation efforts to monitor endangered species, track poachers, and protect natural habitats. These systems often consist of drones equipped with cameras and sensors that can cover large areas efficiently, providing real-time data to conservationists. Example: The "Air Shepherd" program utilizes drones to patrol wildlife reserves in Africa, helping to deter poaching activities and protect endangered species such as elephants and rhinos.

### Entertainment

Robots can be used for entertainment purposes, such as in theme parks or as performers in shows.

### Elderly Care

Service robots can provide assistance to the elderly and people with disabilities, helping with tasks like mobility support, medication reminders, and companionship.

### Multi-Robot Elderly Care Assistance

Multi-robot systems are designed to assist elderly individuals with daily tasks, monitor their health, and provide companionship. These systems may include robots capable of fetching items, reminding individuals to take medication, and detecting falls or other emergencies. Example: The "RoboCoach" project develops a team of robots to assist elderly individuals in maintaining an active lifestyle, providing exercise guidance, social interaction, and cognitive stimulation.

1. Link: RoboCoach
2. <https://robocoach.com.mt/>
3. <https://github.com/RoboCoachTechnologies>

### Logistics and Delivery

Robots are being used for tasks like warehouse automation and last-mile delivery of packages.

# Planning approaches

### Hierarchical Task Network (HTN) (Erol et al., 1994)

Is a planner for high-level decision-making and deliberation, while utilizing Behavior Trees (BTs) for reactive and immediate low-level behavior actions. It breaks down the robot's behavior into distinct and self-contained skills.

HTN are a way of representing tasks and their organization in a structured manner by breaking down complex tasks into smaller, more manageable sub-tasks.

### Behavior Trees (BTs)

For reactive and immediate low-level actions.

### Instantiated HTN (iHTN) (Lesire et al. 2016) formalism takes this kind of high-level plan and makes it more concrete, executable, and actionable. It adds details like who will perform each task, when it will happen, and how it will be done. So, iHTN is like taking a general plan and turning it into a practical, step-by-step guide that can be followed to carry out complex tasks effectively. It's especially useful in areas like robotics and automated planning where detailed execution information is crucial.

### Coordination and Execution of tasks within different environments.

The Environment Descriptors and Skill Descriptors in MissionControl serve essential roles in the coordination and execution of tasks within different environments.

**Environment Descriptors Interface**: This interface within MissionControl simplifies the process of accessing the information needed for coordination tasks. **Skill Descriptors**: Skill Descriptors offer estimates of the cost and utility associated with executing specific tasks using a particular robot. Essentially, they provide information about how suitable a robot is for a given task. These descriptors help MissionControl make informed decisions about task allocation, ensuring that tasks are assigned to robots that are most capable or cost-effective for the job. This optimization is essential for efficient and effective task execution. **Skill Implementations**: Skill Implementations are components within MissionControl that play a crucial role in task execution. They provide the control and instructions necessary for a robot to perform specific tasks. These components bridge the gap between high-level task planning and low-level robot control, ensuring that the robot executes tasks accurately and efficiently. Skill Implementations are the "how-to" guides that enable robots to carry out tasks effectively.

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