CMUSWARM: Full Stack Swarm Architecture

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Motivation

There are many **robotics frameworks...**

ROS Player Orca

Robotics Frameworks

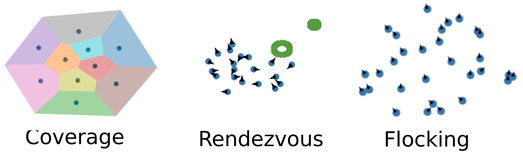
There are many **simulation platforms...**

ARGoS Large-scale robot simulations

GAZEBO MENGE

Simulation Platforms

There are many **swarm algorithms...**



Coverage Rendezvous Flocking

However, swarm robotics researchers must often implement and migrate the numerous swarm algorithms outlined in the literature between these frameworks as they evolve or become deprecated.

Objective

Create a cohesive system that permits swarm robotics researchers to efficiently design, deploy, operate and evaluate robotic swarms.

design: create abstract swarm behaviors.
deploy: implement specializations for specific robotic platforms.
operate: enable human-in-the-loop experiments.
evaluate: benchmark algorithm performance with respect to user-defined metrics.

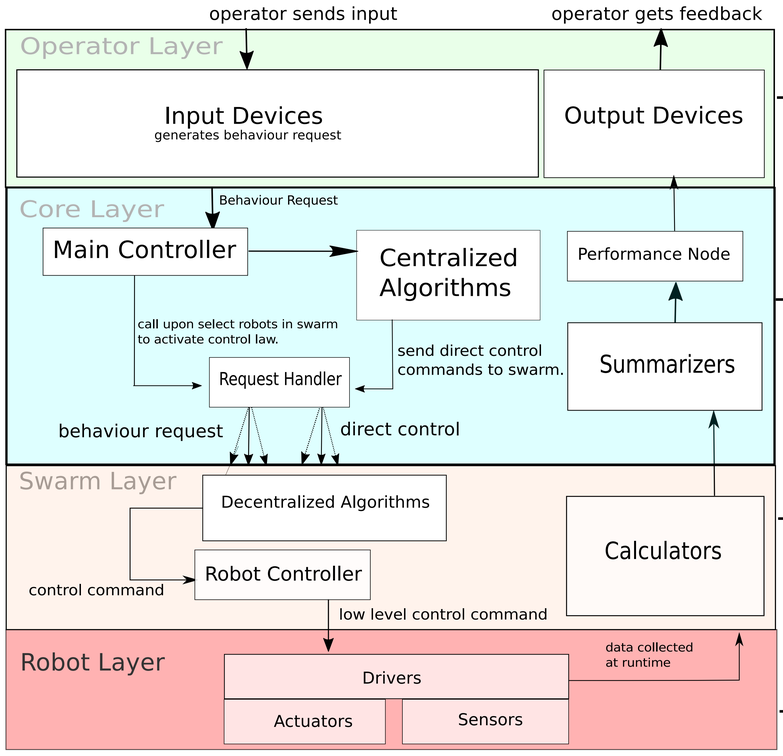
Approach

We design CMUSWARM: A full stack swarm architecture that outlines a design pattern for creating robust swarm applications.

Then we demonstrate and validate a Framework implementation of CMUSWARM on the ROS platform.

Carnegie Mellon University
The Robotics Institute

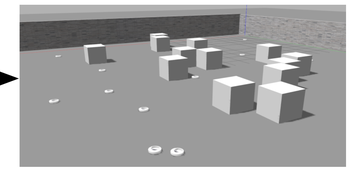
Design



Key Features

Asynchronous publisher-subscriber communication
ROS independent
Supports both centralized and decentralized algorithms

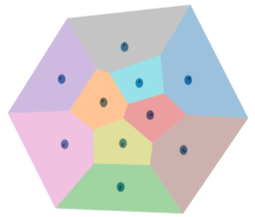
Implementation



Software Agnostic
Real World Ready

ROS

7 ROS Packages
16+ ROS Nodes



6+ Algorithms
3 Performance Metrics

$$\boldsymbol{dv} = -k^i(\boldsymbol{C_i} - \boldsymbol{p_{i,k}})$$

$$\begin{bmatrix} \dot{x}^i \\ \dot{y}^i \\ \dot{\theta}^i \end{bmatrix} = \begin{bmatrix} cos(\theta^i) & 0 \\ sin(\theta^i) & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} u_v^i \\ u_w^i \end{bmatrix}$$

$$\theta_{k+1} = wraptopi(\theta_k + u_w dt)$$

Holonomic and NonHolonomic Robot Dynamics

Validation

The architecture was implemented on ROS and was succesfully able to simulate 32 iCreate robots. Benchmarks for 3 different multirobot algorithms were produced across over 600 automated trials.

Future

Our validation results demonstrate the Frameworks ability to operate as a robust swarm system designed wholly from our full stack architecture. We wish to do future comparative work on swarm algorithms, along with human-swarm interaction experiments using the Framework.

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