SUPERMANDER

SALAMDER-INSPIRED RESCUE ROBOT

INTERDISIPLINARY CAPSTONE DESIGN

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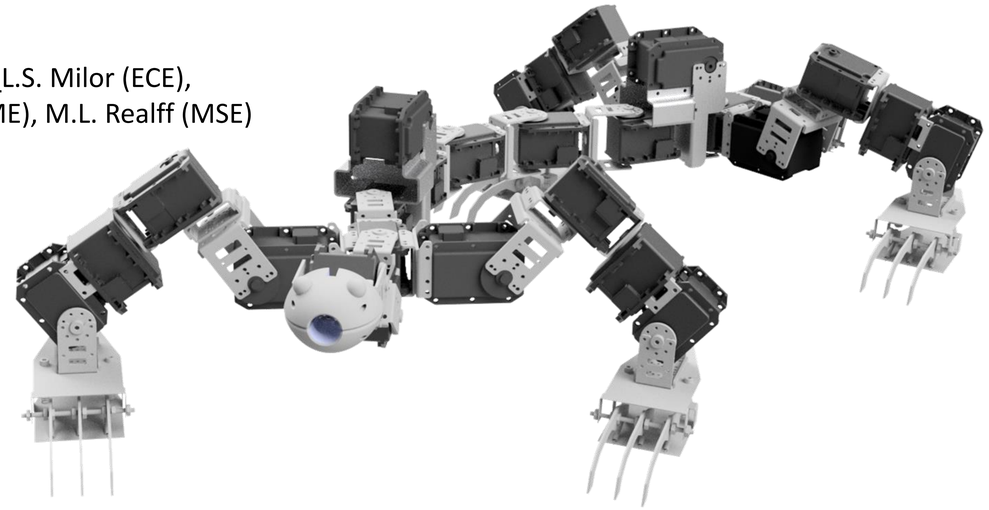
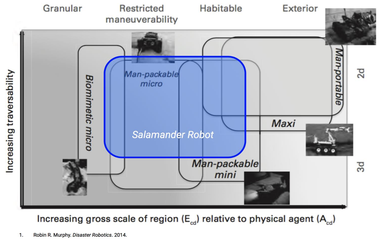


Mission

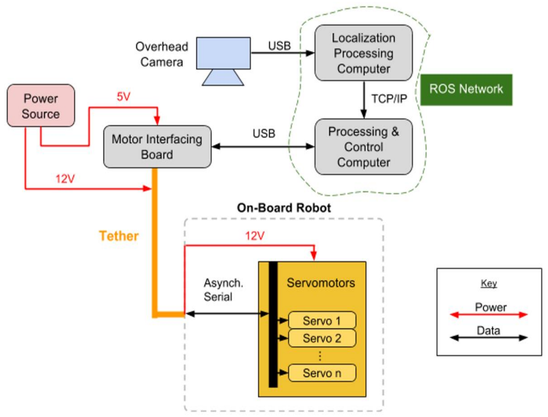
- Design, build, and test a highly articulated, rugged, salamander inspired robot capable of traversing uneven terrain for use in disaster reconnaissance missions.

Motivation

- Increased focus on Disaster Robotics after Fukushima
- DARPA Robotics Challenge - $3.5 M, 24 professional teams
- **Post Disaster Scouting** - first-response ground robots can traverse areas that humans cannot (size, danger, etc.)

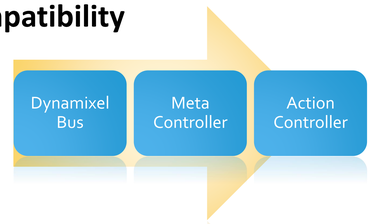


Interfacing Diagram



Solution Characteristics

- 29 Controlled Deg of Freedom
- Static and Dynamic Feet
- Visual and Auditory Communication Equipped
- **ROS (Robot Operating System) compatibility**

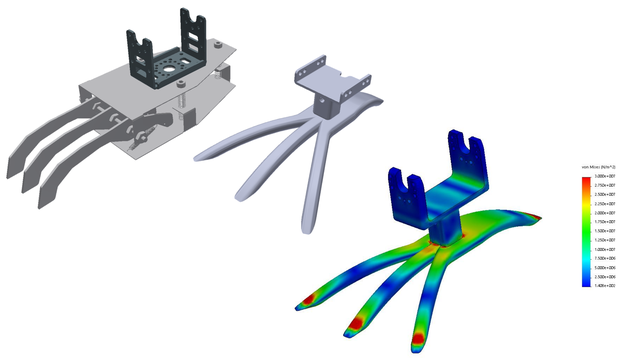


Hardware

- Dynamixel MX-28/MX-64 Servos
- OpenCM 9.04 interfacing board
- Compliant Feet
- Wireless Camera/Mic

Foot Design

- 4 types of feet: (2 static/2 dynamic)



Traversing Speed (ft./s)			
Foot Type	Tile	Carpet	Gravel
Ball Feet	0.2	0.2	0.15
Squirrel Feet	0.12	0.02	-
Badger Feet	0.2	0.2	0.2
Salamander Feet	-	-	-

ME Design

- **Custom spine brackets for vertical movement**
- Bracket compatibility
- Movement constraints/goals
- Testing with different environments, gait, and feet

Full-Body Control

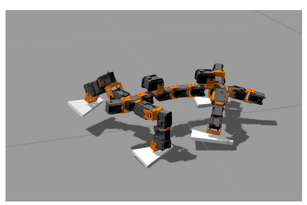
Genetic Algorithm-Optimized Gait

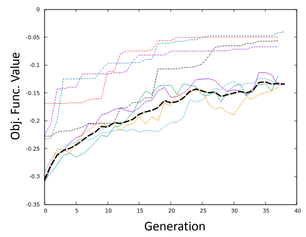
- **Genetic algorithm (GA)** optimizes objective function taking into account goal gait velocity ξgoal and energy costs
- Objective function takes into account motor torque limits
- Gait parameterized with 29 numbers
- Genetic algorithm runs as C++ program within Gazebo dynamics simulation

$$F(\vec{g}) = \|\xi - \xi_{goal}\| - k\int_0^{t_f}\sum_{i=1}^{n}|\hat{\tau}_i(t)|dt$$

$$\hat{\tau}_i(\tau_i) = \begin{cases} \tau_i & 0 < \tau_i < 1/2 \\ 1/2 + k_2(\tau_i - 1/2)^2 & \tau_i > 1/2 \end{cases}$$

$$\theta_i = A_i + B_i\sin(\omega t + \phi_i)$$





Simple Trot Gait

- Simple gait model developed from A. J. Ijspeert's (EPFL) work on bio-inspired salamander movement
- Spine joints have uniform amplitude, and legs contact/lift up from ground only
- 2 feet on ground at a time