AUTOMOTIVE SUMMIT 2014

Green Mobility Changing the World

19 - 20 June 2014

Bitec Bangna, Bangkok

Automotive Summit 2014

Industrial Mobile Robot

By Katiya Greigarn, Ph.D.
KV Electronics Co., Ltd.

June 20th, 2014

Robot

the ultimate automation equipment

Electro-mechanical machine

that are guided by a computer program

or electronic circuitry.

Why using Robots?

R2D2

Ancient Robotic Technology
The mechanical programmable robots

China ~ 1088AD - Water-powered Clocks

Italy ~1945 AD – Leonardo da Vinci, mechanical knight

Japan 19th century - karakuri (tea serving robot)

Etc.

Powered by spring, weight, sand or water, etc.

The word “Robot” is believed to come from Czech word “robota” mean “servitude”

or “ one who serves”

Mr.Yasuo Yamauchi's comment

Quality improvement.

Improvement of working environment.

Better cost effectiveness.

Flexibility to change.

To help people to do certain kind of jobs that we want them to do as equal as or better than we do on our behave.

Classification Overview

- Manipulators – Robot arms, etc.
- Mobile robots
  - Flying(Aerial)
  - Aquatic
  - Terrestrial
- Biological inspired robots
  - Humanoid
  - Non-humanoid

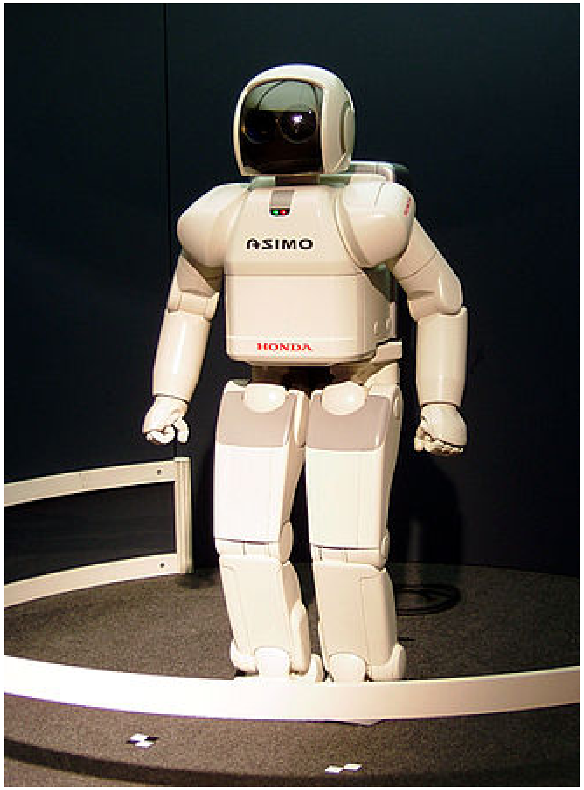
Another consideration

Autonomous

Non-autonomous(human control)

Humanoid

Honda's ASIMO



Nasa's *Robonaut 2 at International Space Station*

Non-humanoid

Spiderbot

Cow robot

Fish robot

serpentine
robot

Industrial Robot Arms

Factory Automation with industrial robots for palletizing food products like bread and toast at a bakery in Germany

Mobile Industrial Robot

http://news.thomasnet.com

Programmable AGV carries up to 900 lb of cargo

Automated Tugger uses magnetic guide-path to transport carts.

Mobile Robots

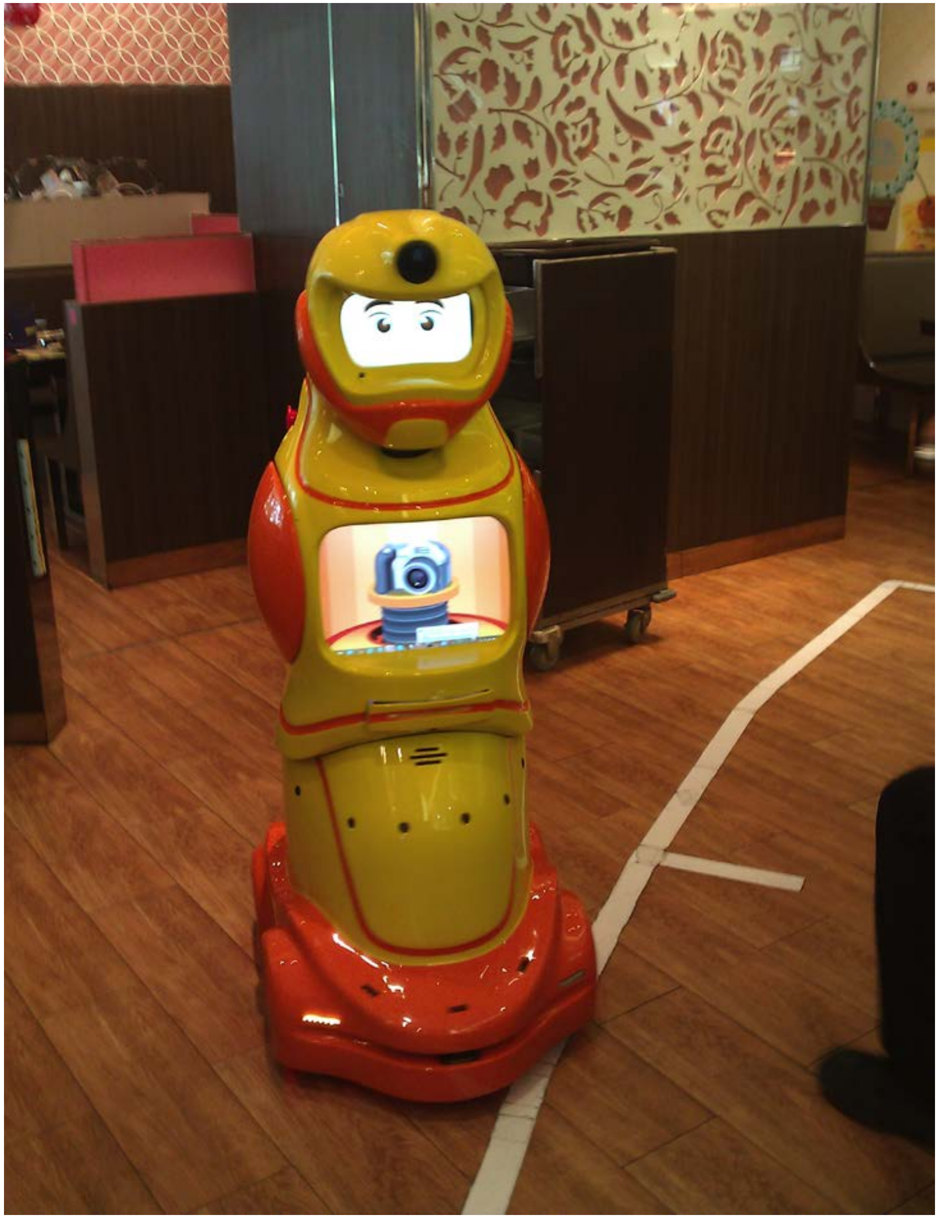
Mobile robots are automatic machines that are capable of movement to a given destination in any given environment.

- Opportunity Robot Rover
- Curiosity Robot Rover

Opportunity Robot Rover

How about Thailand's

MK Robot was at Charmchuri Square



ubot

- Utility Mobile Robot
- CPU 1.6GHz, Memory 1GB, Flash 8GB
- AC Servo Motor 100 watts
- Batteries 24VDC 1,000 watt-hours
- Sensors, Stargazer, Range-finder, Ultrasonic, Bumping micro switch, etc.
- Weight 20 Kg. can carry 80 Kg.
- Localization by Star Gazer and landmark

uBot

Industrial Mobile Robotics

- To able to move autonomously
- To be able to carry loads
- To be able to build map and know its location in the map
- To be able to do path planning
- To be to arrive destination accurately
- To be able to work safely in human environment
- To be able to work collaborately with people

Robots have to be able to accommodate the enormous uncertainty in the real world.

There are a numbers of factors that contribute to robots' uncertainty.

Difficulties

Uncertainty

Complexity

Probabilistic

Implication

Multiple disciplines

Knowledge requirement in Robotics

State estimation

Localization and Mapping

Path planning

Motion control

Perception of environment

Human interaction

Artificial intelligence

Etc.

Mathematical Frame Work
to approximate what would happen
to robot during operation.

Gaussian Estimation

How to estimate environment and robot states from sensors data.

- Kalman Filter (Linear Gaussian Systems)
- Extended Kalman Filter
- Etc.

Nonparametric Estimation

Alternative to Gaussian techniques

Using discrete number of values

- Particle Filter
- Histogram Filter
- Etc.

Localization

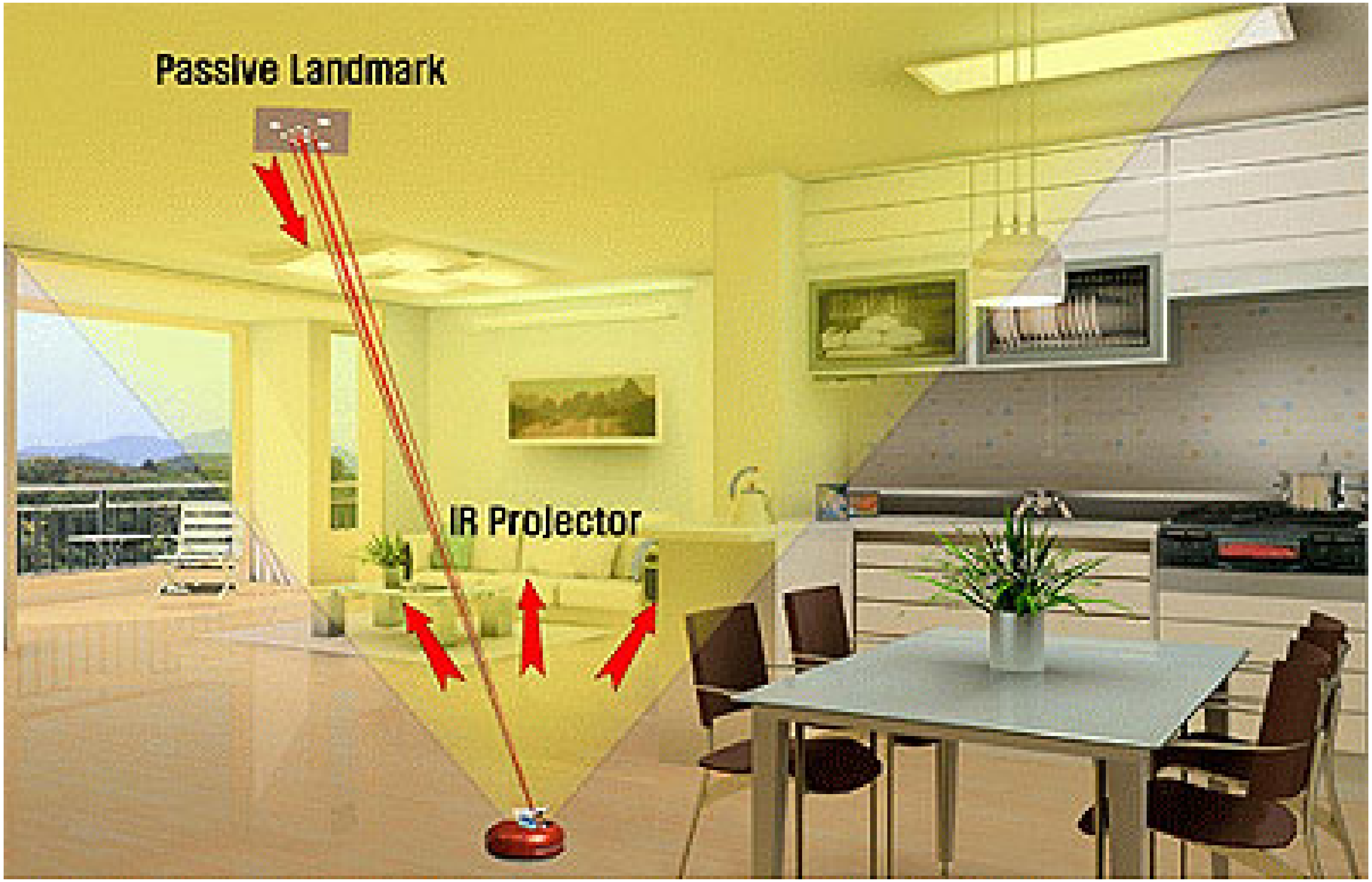
How to estimate robot's coordinate relative to external reference frame.

1) Kalman Filter based localization using gyro−compass, and odometry, etc.
2) Implementation of motion control using Vector Field Histogram (VFH) algorithm (real time motion planning algorithm proposed by Johann Borenstein)

http://cargocollective.com/youjin/Localization-algorithm

3) Landmark

Landmark Localization



Mapping

Occupancy Grid Mapping Algorithm

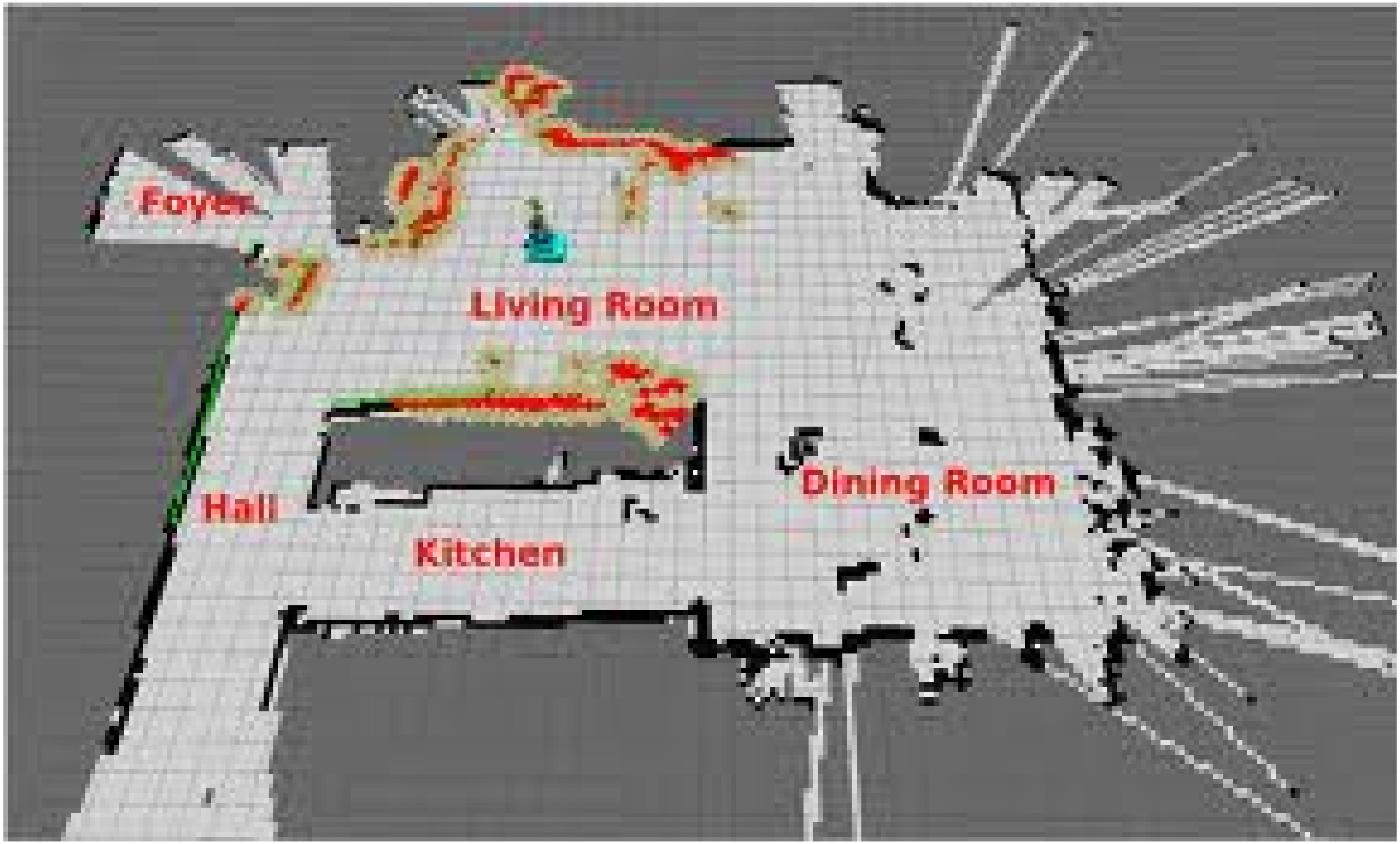
Simultaneous Localization and Mapping

Etc.

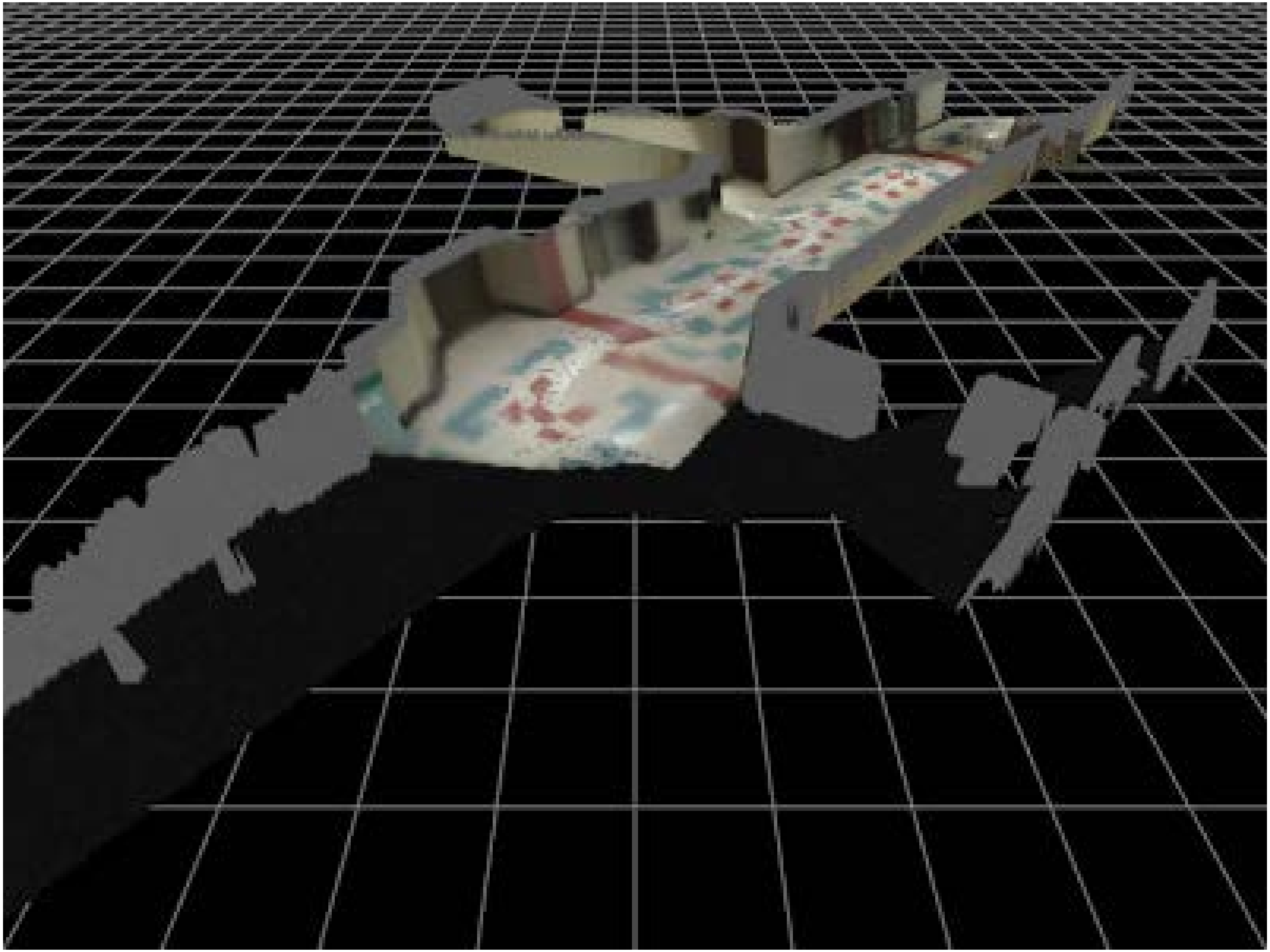
Simultaneous Localization and Mapping

SLAM

Laser rangefinder SLAM



3D camera SLAM



Path Planning and Control

- Decision Processes how to avoid obstacles

and reach destination

- Control System Processes how to move along the planned path

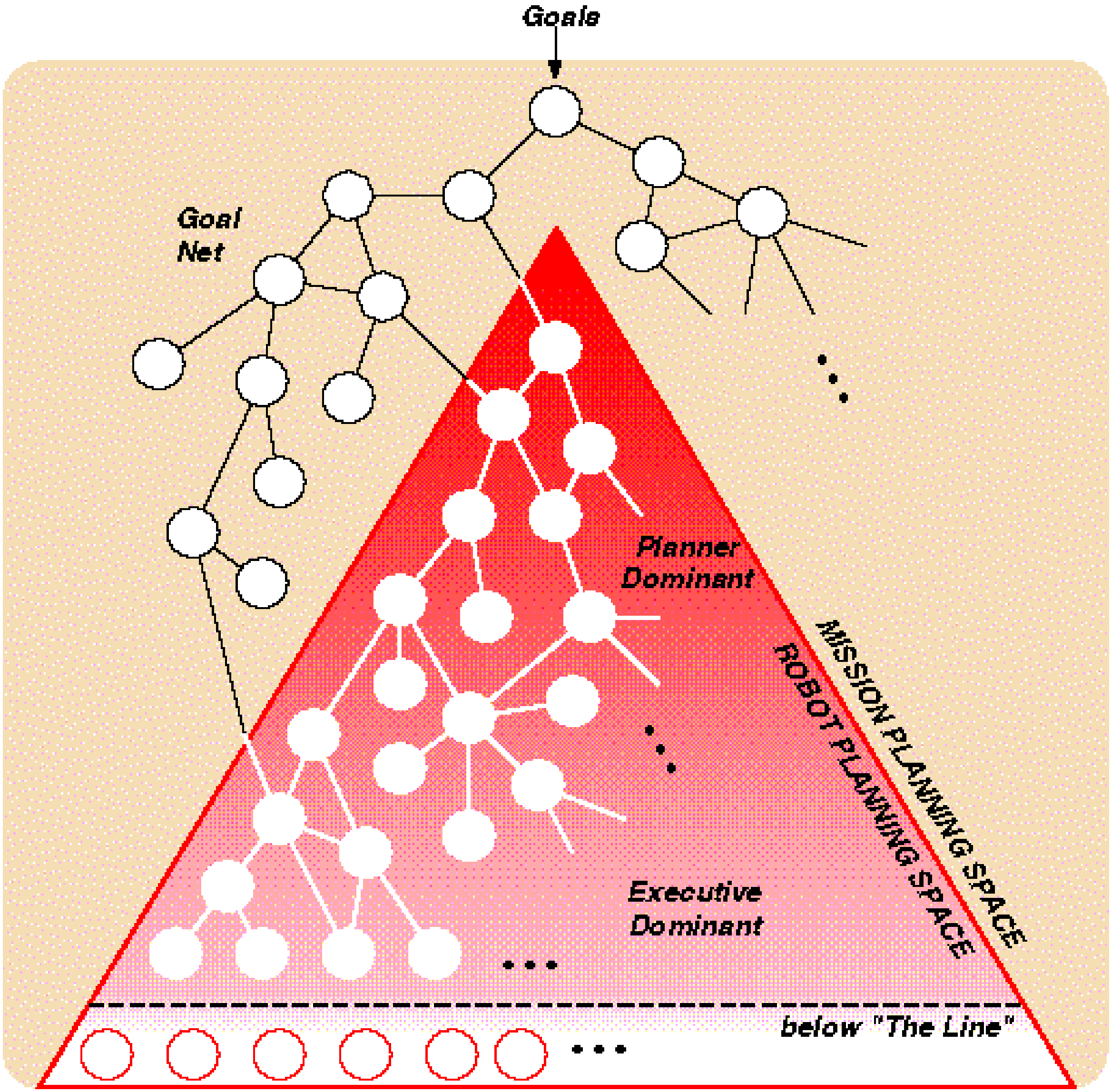
Robot Motion

How to describe Motion models

- Kinematic configuration
- Velocity
- Odometry and
- Direction

Decision Making Processes

Decision-Making in a Robotic Architecture for Autonomy



Control Theory System Consideration

- Static Load/Dynamic Load
- Sensors feedback time delay
- Computational time delay
- Sampling frequency
- Environment noises
- System prediction
- Optimization control
- Stability

Robot Dynamics

Static Load or Dynamic Load ?

How to compensate change in inertia?

Mass of load change << Total Robot mass

Mass of load change >= Total mass of Robot

Implication

- Dynamic load state equation need to re-calculated recursively, consume computational power
- Time delayed for sensors could create instability
- Good system characteristic prediction is needed

Conclusion on Requirement

- Accurate Systems modeling
- Proper Sensors selection
- Good Localization and Mapping algorithm
- Need Feedback Controlling
- Optimized Decision making
- Good Policy Prioritizing
- Environment interaction requirement
- Learning and adapting capability

Sensors

- Bumping micro S/W or touch sensors
- Ultrasonic sensors
- Range Finders sensors
- Magnetic sensors
- Camera and microphone as sensors
- Star Gazer sensor
- Level or Gyro sensors
- Load sensors
- RFID sensors , etc.

Tracking of Mobile Robots for Industries

Tracking accuracy and final position accuracy

Tracking by magnetic tape

Tracking by color tape

Tracking by copper foil (also used as power supply)

Range finder and particle tracking

Star gazer and tracking

Combination of above for higher accuracy

Etc.

Autonomous Software Modules

- Control Theory System Model selection (State Est., Stability)
- Localization algorithm (Kalman/Particle Filter)
- Mapping algorithm
- Motion control algorithm
- Path Policy algorithm
- Feedback control algorithm (PID, Optimization)
- Safety Policy
- Single Robot or Fleet Robot Policy
- Static or Dynamic Loads
- Human user interface

Policy Prioritization

- **Safety policy**
- Data collection
- Various theoretical compliances
- Various application algorithms
- Control and signaling

Who would use Mobile Robots

Service : Hospitals, Libraries, Office environment etc.

Factories :

-Light weight Industries < 100Kgs; Electronics assembly , etc

-Medium weight Industries 100Kgs - 500Kgs

-Heavy weight > 500Kgs

-Very heavy weight > 1,000Kgs

Industrial Benefits

To move materials within factories on demand(JIT/Kanban)

To be able to easily adapt path once production lines are modified or serving multiple requests

To assist and collaborate workers in factories

To learn and perform specific task

To provide task summary report realtime

Etc.

Other Social Benefits

-Robots at home

-Nursery home

-Surveillance or Telepresence

-Etc.

Future Robotic Technology Development

-Exponential development with combined multiple disciplines

-More autonomous

-User friendly interaction and collaboration

-Learning capability

Asking the Right Question

How can we develop robots that are able to learn(can be taught) to help us(people) to do our jobs?

As machines grow ever more intelligent, they're emerging not just as powerful tools, but close companions.

THANK YOU