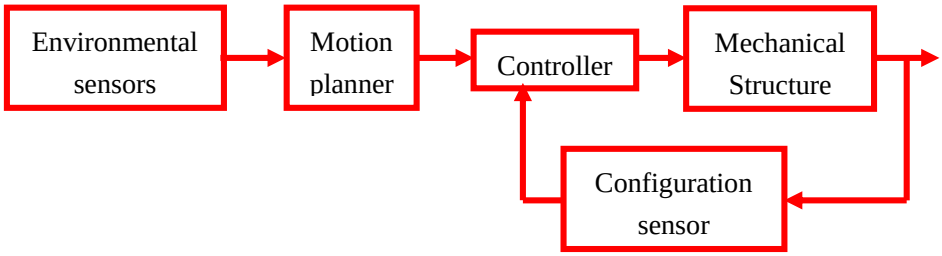
AI 整理

By Gao Biao

一、Introduction

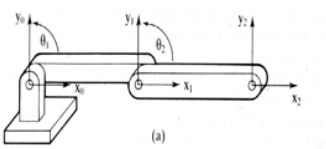
- **AI 的应用**
  - Game playing, speech recognition, computer vision, mathematical theorem proving, natural language understanding, scheduling and planning.
- Application Areas of AI In Robotics
  - Representation, Search, Inference, Learning, Planning
- Robot
  - 定义 1：An automatic device that performs functions ordinarily ascribed to human beings → washing machine = robot?
  - 定义 2： A robot (industrial robot) is a **reprogrammable**, **multifunctional manipulator** designed to move materials, parts, tools, or specialized devices, through variable programmed motions for the performance of a variety of tasks.
  - 定义 3：A programmable machine that imitates the actions or appearance of an intelligent creature–usually a human.
  - 特征：
    - Sensing and perception: get information from its surroundings
    - Carry out different tasks: Locomotion or manipulation, do something physical–such as move or manipulate objects
    - Re-programmable: can do different things
    - Function autonomously and/or interact with human beings
- Why use robots?
  - 4D environments : Dangerous, Dirty, Dull, Difficult
  - 4A tasks : Automation, Augmentation, Assistance, Autonomous
  - Examples: Increase product quality, Increase efficiency, Increase safety, Reduce cost.
- **Robot Applications**
  - Manufacture industry, Biotechnology, Military Applications, Fire Fighting\ Search\ Rescue, Entertainment Industry.
- **Architecture of Robotic Systems**
  - Mechanical Structure: Kinematics model, Dynamics model
  - Actuators: Electrical, Hydraulic, Pneumatic, Artificial Muscle
  - Computation & Controllers
  - Sensors
  - Communications
  - User Interface
  - Power conversion unit

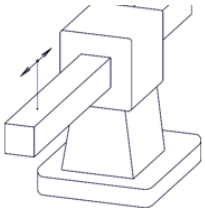
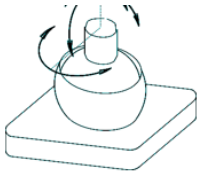


二、Sensor

- Sensor - an electrical/mechanical/chemical device that maps an environmental attribute to a quantitative measurement
- Each sensor is based on a **transduction principle** - conversion of energy from one form to another
- Sensor Fusion & Integration
  - Sensor fusion: Combine readings from several sensors into a (uniform) data structure
  - Sensor integration: Use information from several sensors to do something useful
  - **Why sensor fusion ？？**
    - Real sensors are noisy
    - Limited Accuracy
    - Unreliable - Failure/redundancy
    - Limited point of view of the environment
    - The sensor of choice may be expensive
- **Sensors Used in Robot**
  - Compass, Lidar, Sonar, IMU, Encoder…
- Basic Navigation Techniques
  - Relative Positioning (called Dead-reckoning 航位推算法)
    - Problems: unbounded accumulation error
  - Absolute Positioning -- Magnetic Compasses, GPS …

三、Kinematics

- 

Revolute Joint
1 DOF (Variable - Y)
- 
Prismatic Joint
1 DOF (linear) (Variables - d)
- 
Spherical Joint
3 DOF (Variables - Y_1, Y_2, Y_3)
- Two kinematics topics
  - Forward Kinematics (angles to position)
  - Inverse Kinematics (position to angles)

四、Mobility

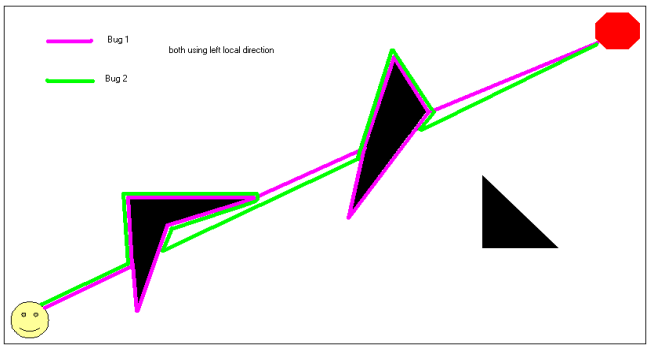
- Differential Drive
  - Advantages: Cheap to build, Easy to implement, Simple design
  - Disadvantages: Difficult straight line motion
- Skid Steering(履带式)

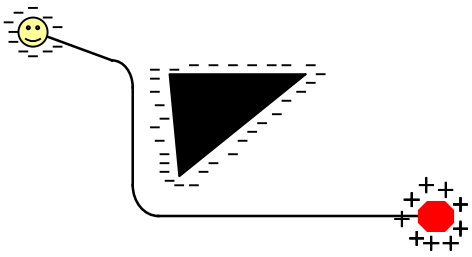
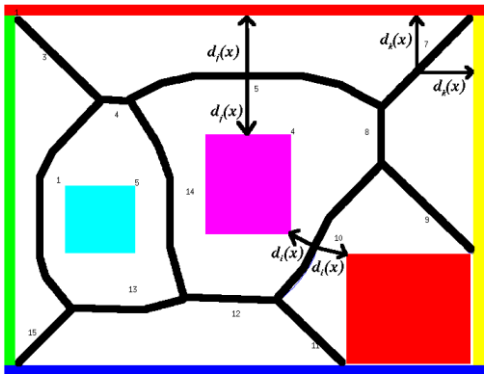
- Advantages: Simple drive system
- Disadvantages: Slippage and poor odometry results, Require a large amount of power to turn

- Synchro Drive
  - Advantages: Separate motors for translation and rotation makes control easier,
    Straight-line motion is guaranteed mechanically
  - Disadvantages: Complex design and implementation
- Omni Wheels
  - Advantages: llows complicated motions
  - Disadvantages: No mechanical constraints to require straight-line motion
    Complicated implementation
- Tricycle
  - Advantages: No sliding
  - Disadvantages: Non-holonomic planning required
- Ackerman Steering
  - Advantages: Simple to implement
  - Disadvantages: Non-holonomic planning required
- Articulated Drive:
  - Advantages: Simple to implement except for turning mechanism
  - Disadvantages: Non-holonomic planning is required
- Framewalker
  - Advantages: Separate actuation of translation and rotation
    Straight-line motion is guaranteed mechanically
  - Disadvantages: Complex design and implementation
    Translation and rotation are excusive
- Snake Robots
  - Advantages: Many applications, Hyper-redundant
  - Disadvantages: Complex control and planning
- Legged Robots
  - Advantages: Can traverse any terrain a human can
  - Disadvantages: Large number of degrees of freedom
    Maintaining stability is complicated

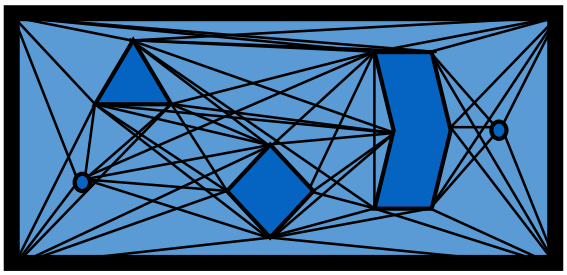
五、**Motion planning**

- The world consists of **Obstacles** & **Free Space**
- The Configuration Space
  - What it is ?
    A set of “reachable” areas constructed from knowledge of both the robot and the world
  - How to create it ?
    -Abstract the robot as a point object.
    -Enlarge the obstacles to account for the robot’s footprint and degrees fo freedom
- Lumelsky Bug Algorithms

- 

  - Unknown obstacles, known start and goal.
  - Simple “bump” sensors, encoders.
  - Choose arbitrary direction to turn (left/right) to make all turns, called “local direction”
  - Motion is like an ant walking around
- Potential Functions
  - 
- The Wavefront Planner
  - A common algorithm used to determine the shortest paths between two points
  - Representations: A Grid
7	**18**	17	16	15	14	13	12	11	10	9	9	9	9	9	9	9
6	17	17	16	15	14	13	12	11	10	9	8	8	8	8	8	8
5	17	16	16	15	14	13	12	11	10	9	8	7	7	7	7	7
4	17	16	15	15	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	6	6	6	6
3	17	16	15	14	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	5	5	5	5
2	17	16	15	14	13	12	11	10	9	8	7	6	5	4	4	4
1	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	3
0	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	**2**
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
- Roadmap Theory
  - 

  - A GVG is formed by paths equidistant from the two closest objects

- Visibility Graph
  - 

六、Computer Vision

- What is Computer Vision
  - Input: images or video;
    Output: description of the world
    But also: measuring, classifying, interpreting, visual information
- 3 Levels of Vision
  - Low: Consider local properties of an image
  - Mid: Grouping and segmentation
  - High: Recognition
- **Applications**
  - In AI: vision serves as the “input stage”
  - In medicine: understanding human vision
  - In engineering: model extraction
  - **Low-Level (tech: Filters): Corner Detection, First stage of segmentation, Texture recognition/ classification**
  - **Mid-Level (tech: Clustering…): Segmentation / grouping, tracking**
  - **High-Level (tech: Bayesian networks, Templates…): Face detection, Principal Components Analysis(PCA), 3D scanning**

七、Computer Speech

- Speech Recognition
  - Applications
    Speech to text dictation, Voice controlled systems, Automated enquiry services
  -
- Speaker Identification
  - Applications
    Surveillance and forensics, voice controlled entry systems, Secure access to ATMs
  -
- Speech Synthesis
  - Applications
    Automated information systems, Computer games, Aircraft cockpit flight information
- **Why is it difficult to process speech?**
  - Speech signals are continuous.
    Speech signals are highly variable.

Speech is ambiguous.

Speech is contaminated.(influenced by noise)

Speech is highly complex.

- Automatic Speech Recognition (ASR)
  - An ASR system converts the speech signal into words
  - 3 Stages:
    - Front-end for feature extraction (feature vectors)
    - Pattern matcher for word or phoneme recognition
    - Language model for sentence recognition
- Another View for Speech Recognition System
  - How to represent the signal
  - How to model the constraints
  - How to search for the most optimal answer
- Basic Speech Recognition Challenges
  - Co-articulation
  - Speaker independence
  - Spontaneous speech
  - Language modeling
  - Noise robustness