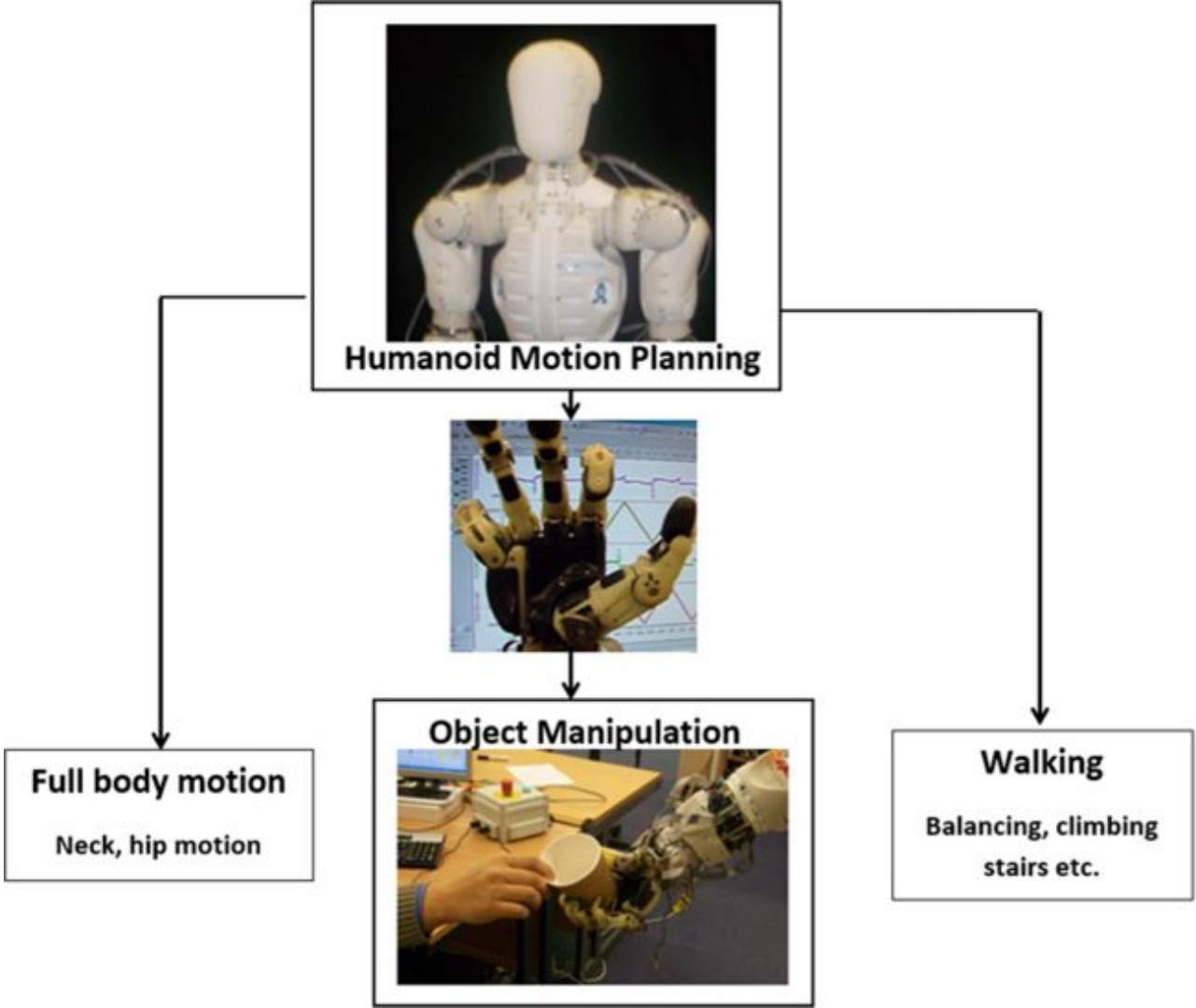
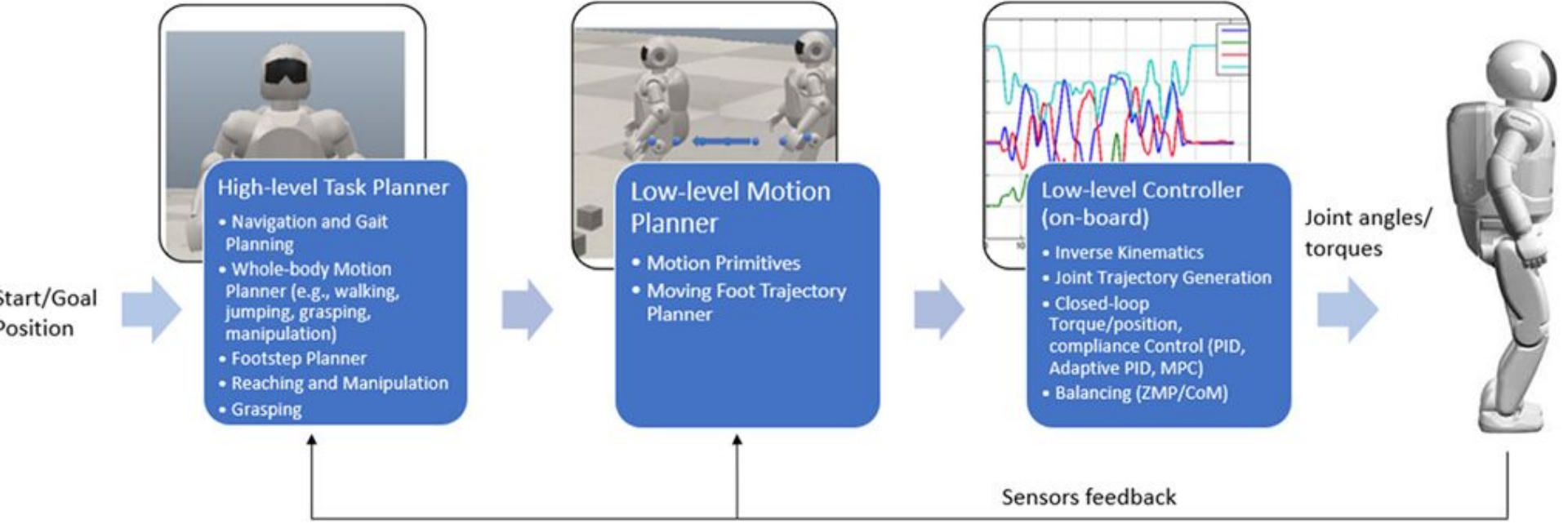
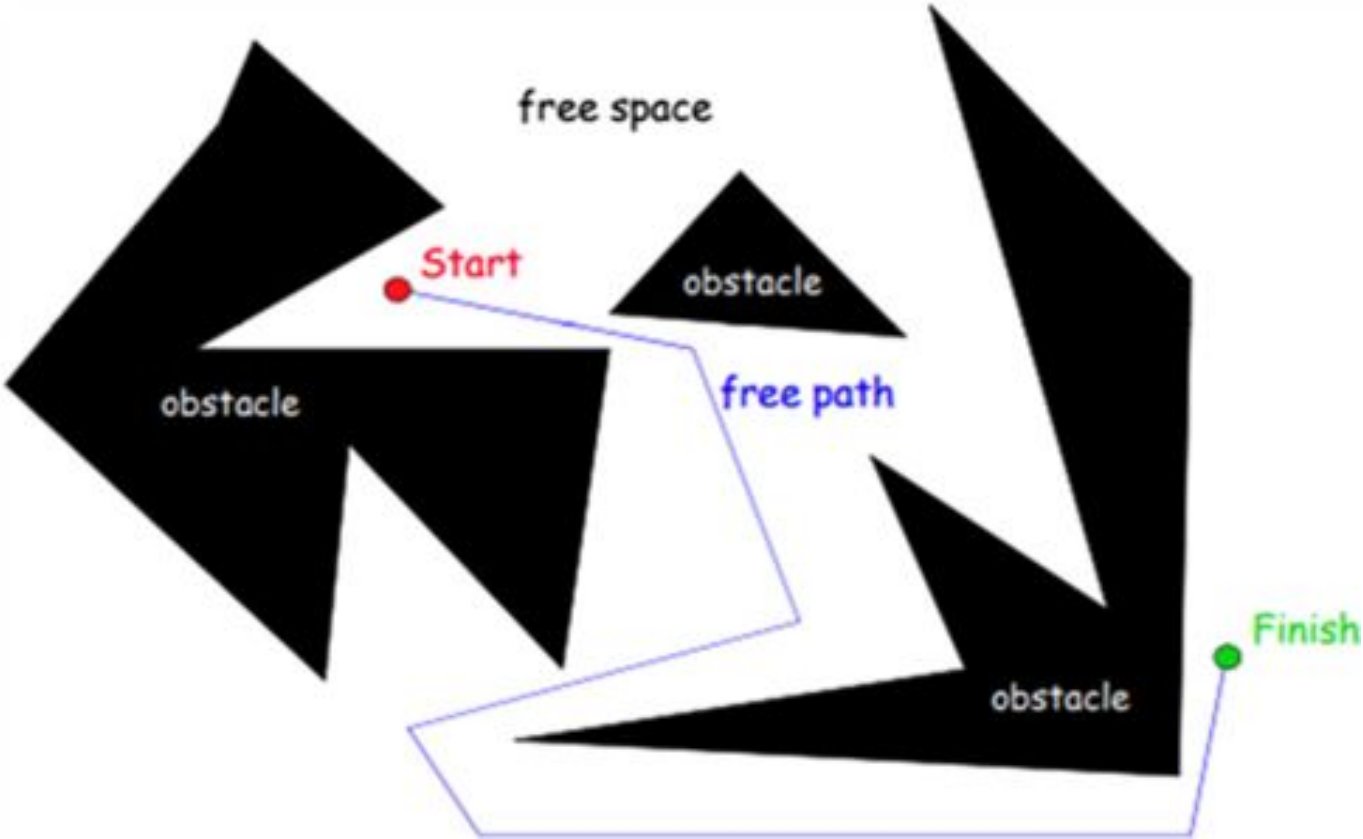
Humanoid Robot Motion Planning Approaches: a Survey

Giới thiệu và phân loại





Khung lập kế hoạch path planing cho humanoid robot


free space
Start
obstacle
obstacle
free path
Finish
obstacle

Các phương pháp tiếp tiếp cận:

- **Human-Inspired Approaches**
- **Inverted Pendulum Approach - IPA**
- **Kinematic Constraints Approaches**
- **Motion Planning Using AI Techniques**

1. Human-Inspired Approaches

Paper Name	Main Problem	Main Approach to Solve It	Simulation	Real Robot Application	Robot's Name
[4]	Robot locomotion in various environments	Two-tiered system with Highlevel controllers determining action timings and low-level controllers executing walking patterns	Yes	No	DeepLoco
[60]	Humanoid motion planning for robotic arms, especially in vulnerable scenarios	Data collection through VICON system, decoding humanoid motion rules, training robotic arm using DDPG and HER algorithms	Yes	Yes	Not Available
[1]	Traverse significant obstacles for humanoid robots	Multi-body contact motion planning based on human demonstrations using a wholebody control technique	Yes	No	Not Available
[61]	Human-like trajectories for anthropomorphic robots' upper limbs	Human-likeUpper-limbMotion Planner algorithm that integrates human motor control theories adjusting spatial and	Yes	Yes	HUMP

2. Inverted Pendulum Approach - IPA

Phương pháp con lắc ngược (Inverted Pendulum Approach - IPA) là một kỹ thuật phổ biến trong motion planning cho robot hình người. IPA mô hình hóa chuyển động của robot như một con lắc ngược, với phần thân robot là khối lượng chính và các khớp là các khớp nối.

3. Kinematic Constraints Approaches

Tên giấy		Vấn đề chính	Cách tiếp cận chính để giải quyết nó	Mô phỏng	Thực Ứng dụng robot	Tên robot
[17]		Lập kế hoạch chuyển động	Đa liên hệ cử động Lập kế hoạch liên quan đến tiếp xúc không phẳng và theo chu kỳ	Có	Không	Không có sẵn
[18]		Tốc độ đi bộ ổn định	Thuật toán tăng tốc cánh, một thuật toán để điều chỉnh bước chân mong muốn	Có	Không	Bản đồ mô hình
[20]		Bộ điều khiển phục hồi cân bằng	Kiểm soát dự đoán mô hình số (N-MPC) bằng cách dự đoánthebestway để duy trì sự cân bằng chống lại nhiễu loạn	Có	Không	Không có sẵn
[21]		Robot hình người vận động mạnh mẽ	NonlinearModelPredictiveControl Khung (NMPC)	Có	Không	Không có sẵn

4. Motion Planning Using AI Techniques

Paper Name	Main Problem	Main Approach to Solve it	Simulation	Real Robot Application	Robot's Name
[25]	Path planning ensuring dynamic stability	Modify randomized path planning techniques and apply dynamic filtering function	Yes	Yes	Not Available
[59]	Humanoid robot executing acrobatic behaviors	Integrated hardware design, motion planning considering actuators' limits	Yes	No	MIT Humanoid Robot
[32]	Dynamic activities of humanoid motion planning	Two-stage solution: kinematic and geometric motion planner followed by dynamic walking pattern generator	Yes	No	Not Available
[63]	Improving maritime strategy of humanoid robots	Controller combining fuzzy logic, neural networks, and Petri nets	Yes	No	Not Available
[26]	Navigation on steep and uneven surfaces	Analysis of surface contact before taking a step	Yes	No	Model Robot HRP-2
[14]	Real-time re-planning for obstacle detection	Software architecture for real-time planning and re-planning	Yes	Yes	Robot Robot HRP-2
[15]	Tasks in structured environments	Robots working autonomously in environments structured to their needs	Yes	Yes	Robot ARMAR-III
[10]	Design of stances and postures	Best-first strategy with inverse kinematics-and-statics solver	Yes	No	Not Available
[72]	Online whole-body motion planning for legged robots	BiConMP: nonlinear MPC framework	Yes	Yes	Not Available
[12]	Ladder-climbing abilities	Planning method adhering to contact, collision, and torque constraints	Yes	No	Hubo-II+
[13]	Optimal control in cluttered environments	Automatic generation of bounding capsules around robot body geometries and distance restrictions	Yes	Yes	Model Robot HRP-2
[9]	Dealing with obstacles with appropriate motion sequences	Use bumper sensors and monocular camera	Yes	Yes	NAO
[11]	Dynamic planning, control in challenging environments	Optimization technique with robot's whole kinematics and centroidal dynamics	Yes	Yes	Robot Atlas
[16]	Humanoid's full-body trajectory planning	Gesture planner based on key pose generation satisfying constraints	Yes	No	Not Available

Paper Name	Main Problem	Main Approach	Robot Name
[76]	Autonomous motion planning in unpredictable environments	DRL-based motion planners	Not Available
[80]	TAMP in real-world scenarios	Integration of High-level reasoning and geometric considerations	Not Available
[83]	Efficient training for DRL-based path planning	Incremental training (2D to 3D)	Robot Turtlebot2
[84, 86]	DRL agents in obstacle-rich environments	Motion planners integrated into action space	Robot Arm Sawyer
[85]	Kinodynamic motion planning	RRT* with continuous-time Q-learning	Not Available
[87]	Conveying clear intentions in human-robot interactions	Actor-critic method	Not Available
[89]	RL-driven industrial robot for Industry 4.0 tasks	RL-driven methods for tasks like welding and cutting	Not Available
[91]	Social navigation for robots	Neural networks for path planning as a classification problem	Not Available
[92]	Computational complexity in sampling-based Motion Planners	DeepSMP neural network-driven sampler	Robot UR6
[95]	AI mastering complex tasks without prior knowledge	Reinforcement learning (AlphaGo Zero)	Not Available
[96]	Understandable and explainable AI	"Theory of mind" in AI systems	Not Available
[100]	Applicability of Behavior Trees in robotics	Behavior Trees	Not Available