Autonomous and Interactive Behaviors of Humanoid Robots

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This presentation describes our research efforts aimed at developing several low-level autonomous capabilities required for remote-operation tasks involving humanoid-type robots. Low-level autonomy falls into three categories: 1) perception functions such as 3D vision, map building, and obstacle detection, 2) planning functions such as footstep planning, moving trajectory generation, and grasping trajectory planning, and 3) control functions such as online walking dynamic balance compensation, walking trajectory generation, and so on.

Recently, research on humanoid-type robots has become increasingly active, and a broad array of fundamental issues are under investigation. In particular, techniques for bipedal dynamic walking, soft tactile sensors, motion planning, and 3D vision continue to move forward. However, in order to achieve a humanoid robot that can safely operate in human environments, not only the fundamental components themselves, but also the successful integration of these components will be required. At present, most humanoid robots that have been developed have been designed for bipedal locomotion experiments. In order to satisfy the functional demands of locomotion as well as high-level behaviors, humanoid robots require good mechanical design, hardware, and software that can support the integration of tactile sensing, visual perception, and motor control.

Autonomous behaviors are currently still very primitive for humanoid-type robots. It is difficult to conduct research on high-level autonomy and intelligence in humanoids due to the limitations of both software and hardware. Thus, we took a bottom-up approach to study low-level autonomy of the humanoid robots. We believe low-level autonomous functions will be required in order to conduct research on higher-level autonomous behaviors for humanoids.

Keywords:
ZMP (Zero Moment Point): The point where moment forces around pitch and roll axis become zero. COP (center of pressure) is commonly used in the biomechanics field. Most biped humanoid robots use this index to generate a stable walking trajectory.

Configuration space of humanoid robot: High-dimension space that each joint angle corresponds to axis in most cases. A point in this space represents a posture of the robot. Search algorithms explore this space to find out a solution (such as stable posture or trajectory)

Trajectory: Sequence of posture that forms a robot motion.

Hard realtime: The software task given with the time to execute. The word "hard" means that if it fails to execute at given time, it causes a catastrophic effect on the system. (<-> soft realtime).