Topic: 0-Step-Capturability with Multicontact

*“Capturability-Based Analysis and Control of Dynamic Scrambling with Multiple Contacts on Rough Terrain”*

*“A Computational Approach for Push Recovery in case of Multiple Noncoplanar Contacts”*

*“Zero Step Capturability for Legged Robots in Multicontact”*

*“Capturability-based Pattern Generation for Walking with Variable Height”*

For given contact points (or surfaces), maximum force and friction constraints found the region of the resultant total forces that can be applied on a given center of mass, the maximum force for each direction (Possibly Polyhedral). Analyze convexity by moving the center of mass, how that total forces moves with it. After that, we can found necessary or sufficient conditions for Dynamic Stability.

Some papers try to minimize Kinetic Energy to stop the robot. Minimizing Instantaneously the Kinetic Energy is sufficient if the CoM is over the static stability region. Otherwise there is risk of falling and you cannot be able to running/jumping/parkouring. Develop an algorithm for stabilizing even outside the static stability region.

Topic: Inclusion of Angular momentum and Impacts in Capturability:

LIP and VHIP always push away the Instantaneous Capture Point from the Center of Pressure for 1-step Capturability. The FlyWheel Inverted Pendulum FWIP can move the “Center of Pressure” forward or backward by applying torque so it can move in *any* direction the Instantaneous Capture Point even for a single point foot. Depending on the initial conditions, the region of stability can be highly increased by using Angular Momentum. In planning stage we can place the ICP outside the support foot so the walking will be even more straight-forward.

Impacts can be useful if they absorb momentum and kinetic energy to stop the robot in the space or in the angular momentum limits (Hitting maximum angle can be considered an impact). We can Analyze reset maps for stability.

Topic: Analyze the 3D VHIP as a Hybrid System for general locomotion:

3D VHIP can change the amount of force to the CoM at the cost of having a Variable Height. This can be even useful for walking on Rough Terrain. We can find the Capture region for 1-step Capturability and later make planning over it. We can consider three stages single support, double support and flying stage. By combining those we can have normal walking, running, jumping or parkour-ing. We can analyze also the switching between those stages (modes) through the maximum distance of the CoP and the CoM (guard) and make trajectory optimization over the hybrid system. Actually the SLIP model for running is a particular case of the VHIP. We can have more dynamic runnings than SLIP itself.