Humanoid Collision Reflex Sequences based on an artificial Robot Nervous System including Contact Location and Direction

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I. INTRODUCTION

Reflexive motions have proven to be a valuable tool for preventing damage from robotic arm manipulators and also humanoids to prevent robot falls. Up to now, proprioceptive sensors like accelerometers, gyroscopes and force-torque-sensors were mostly used to generate characteristics like zero moment point (ZMP), Center of Pressure (CoP), tilt angle or velocity of robot links or corrected Capture Point (CCP) [1], [2], [3]. Reflex reactions such as freeze, steps or safe falling motions are activated based on rather heuristic classification or thresholding [1]. These approaches, however, gain information only from the caused effects of disturbance forces rather than from contact properties themselves. Reflexes on the humanoid “Cog” where triggered using the superposition of biologically inspired predefined postural primitives [4].

In this paper, we extend the artificial Robot Nervous System (aRNS) framework [5] to humanoid robots. This makes it possible to use exteroceptive and interoceptive information for designing capable reflex movements.

II. HUMANOID REFLEX CONTROL

The contact dynamics between any suitably controlled humanoid (via the desired torque \( \tau_d \)) and a colliding object with state \( x_c \) are determined by the generalized coordinates \( q \) and the vector of generalized external forces \( \tau_{ext} \) that is caused by the contact wrench \( F_c \) or stress \( \sigma_c \) (single point contact) acting on the collision object and the humanoid, respectively, see Fig. 1.

The aRNS for humanoids is split into five parts: the nervous robot tissue, the aRNS spiking model, the classification, the reflex strategy and the control law. Collision severity is represented by the firing rate of the artificial Robot Neurons (aRNs) depending on penetration depth \( \delta \), velocity \( \dot{\delta} \) and \( \sigma_c \). The contacts are then classified by suitable algorithms into the classes: soft, light, moderate and severe. Note that other schemes are obviously possible as well. In correspondence to these classes and based on collision location \( \alpha \) and orientation \( \alpha \), we design different context dependent reflex strategies, see Fig. 2.

III. EXAMPLE

The reflex movements are visualized using a dynamic simulation model of the Atlas robot. Two examples of possible collisions and according reflex movements at the leg and the arm are shown, see Fig. III.

In Fig. III (a), one moderate contact at the right knee results in a step to the left away from the contact direction. In Fig. III (b), one light contact at the right lower arm leads to a retraction of the upper body and weight-shifting to the left leg, away from the collision.

REFERENCES