MECHANICAL ENGINEERING SEMINAR

Wednesday, March 20, 2023 at 13:30, Dan-Kahn Building, Room 217, and ZOOM LINK

How mammals solve an unsolvable energetic problem of a planar serial-linkage leg

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In terrestrial locomotion of both animals and robots, most of energy is spent during leg contact with the ground for mechanical antagonism between muscles/actuators. The antagonism is the existence of positive muscular work cancelled out by the negative muscular work. In fact, this phenomenon is inevitable in any planar serial-linkage leg. A general way to minimize the amount of mechanical antagonism is the redundancy of degrees of freedom (DoFs) in the leg and their proper sequential switching on and off. In a simplistic model of equilibrium walking, the problem of minimization of the inter-actuator antagonism has a general solution for any number of serial leg segments. The solution implies immobilization (switching off) of all joints except the two. Which two, depends on their instantaneous positions relative to the vertical line through the point of foot contact with the ground. So, regardless of the number of joints, the leg should optimally act as a temporary two-joint linkage. The next step to further reduce the inter-actuator antagonism is the adjustment of the horizontal fore-and-aft component of the ground reaction force (GRF). The optimum solution implies that, during the contact phase, the GRF vector is redirected so as to maintain alignment with the leg joints in the order in which they attain the smallest angles to the vertical line through the foot. As the joints pass this line one by one, abrupt changes of the horizontal GRF component from negative (braking) to positive should occur. However, animals cannot switch muscles on and off immediately and, therefore, they tend to align the GRF with some compromise target point located above the hip (for the hind leg) or above the withers (for the foreleg). The suggested principles for the optimal switching of redundant DoFs and direction of the GRF can be implemented in robotics to reduce the cost of transport.

Short bio: Alexander Kuznetsov graduated from the Biological Faculty of the Moscow Lomonosov State University in 1983 as a master in zoology and botany. Throughout his scientific career, his main topic of research was biomechanics of locomotor apparatus of mammals and other vertebrate animals, their walking and running on land. He started his research as a member of the Laboratory of Bionics working on biological prototyping of legged robots with a powerful team of the Institute of Mechanics of the Moscow University under the leadership of Professor Yevgenii Devyanin. His dissertations were devoted to the general structural features of the legs of mammals and birds from the point of view of their optimality in terms of energy expenditures for muscular work during locomotion on land. At the beginning of March 2022, he was forced to emigrate from Russia because of sharp disagreement with Putin's invasion into Ukraine. In March 2023 he has repatriated in Israel and got an opportunity to continue his research on bio-inspired legged robots at Technion under the leadership of Assoc. Prof. Yizhar Or.

Seminars Coordinator: Assoc. Prof. Gal Shmuel .