POPULAR SCIENTIFIC ABSTRACT

Peter Billeschou

Versatile Bio-Inspired Legged Robots: Developing Mechatronics with High Mobility, Feasibility, Durability, and Power Density

Legged robots have long been in our imagination, as a companion in our daily life, and as an intelligent peer whom humanity together with can socialise, solve complex challenges and be relied on. As such, legged robots have the potential of being a reflection of ourselves and our capabilities. However, tremendous efforts in research and development are needed, as current-day legged robots are far from such levels of versatile functionality. Furthermore, legged robots have still not reached a broader practical usage in real-world applications. In this regard, research in the fields of artificial intelligence and robot control enable legged robots to perform more agile movements, but hardware advances are also needed to enable greater stability and sufficient functionality before a wider variety of applications can be performed. Therefore, legged robots' hardware performance needs particular attention, as they are the base structure from which all other functions derive. As such, greater versatility can be obtained by developing mechatronic structures and components that provide greater mobility, feasibility, durability, and power density, which enable legged robots to fulfill a broader range of tasks in dusty, wet, and hazardous environments. Various research paths can increase the versatility of legged robots; I choose to investigate and develop new legged robot morphologies, leg- and joint mechanisms, powerful actuators, and force/torque sensors, as they were found to limit versatility the most.

In this dissertation, I present my research into such hardware through four manuscripts, starting with (I) establishing a framework for developing bio-inspired robot morphologies and subsequently designing (II) robot legs and their joint transmissions, (III) -actuators, and (IV) -foot sensors. Part I presents and substantiates the framework with a study that developed and analysed a dung beetle-inspired robot, which enables 50% longer steps and 95.5% greater utilisation of the work envelope, and reduces motor accelerations by 7.9% and the impact frequency by 21.1%. Part II presents a compliant mechanism that reduces leg joints' mass by 77.4%, brings down cost by 12.1%, and enables full water submersible and predictable mechanical behaviour. Part III explores options for a durable and power-dense actuation system and presents a concept for a synthesising transmission. Finally, part IV presents a three-axis force/torque foot sensor that reduces mass by 76.5%, volume by 39.1%, cost by 85.3%, and enables excellent accuracy and submersion beyond 3 meters.

Hence, this dissertation presents and provides tools for obtaining more versatile legged robots' through hardware improvements in terms of mobility, feasibility, durability, and power density.