A model for posture adaptation of legged robots while navigating confined spaces

February 14 2019, by Ingrid Fadelli

Credit: Kottege et al.

Multi-legged robots are capable of navigating a variety of complex and unstructured terrains. Their many degrees of freedom allow them to adapt their walking posture to navigate several challenging environments, including confined spaces.

Nonetheless, the most popular and commonly used multi-legged platforms cannot perform this adaptation autonomously. To address this limitation, researchers at CSIRO (Commonwealth Scientific and Industrial Research Organisation), in collaboration with ETH Zürich, have recently devised a new approach that allows legged robots to autonomously change their body shape based on the environment they are operating in.

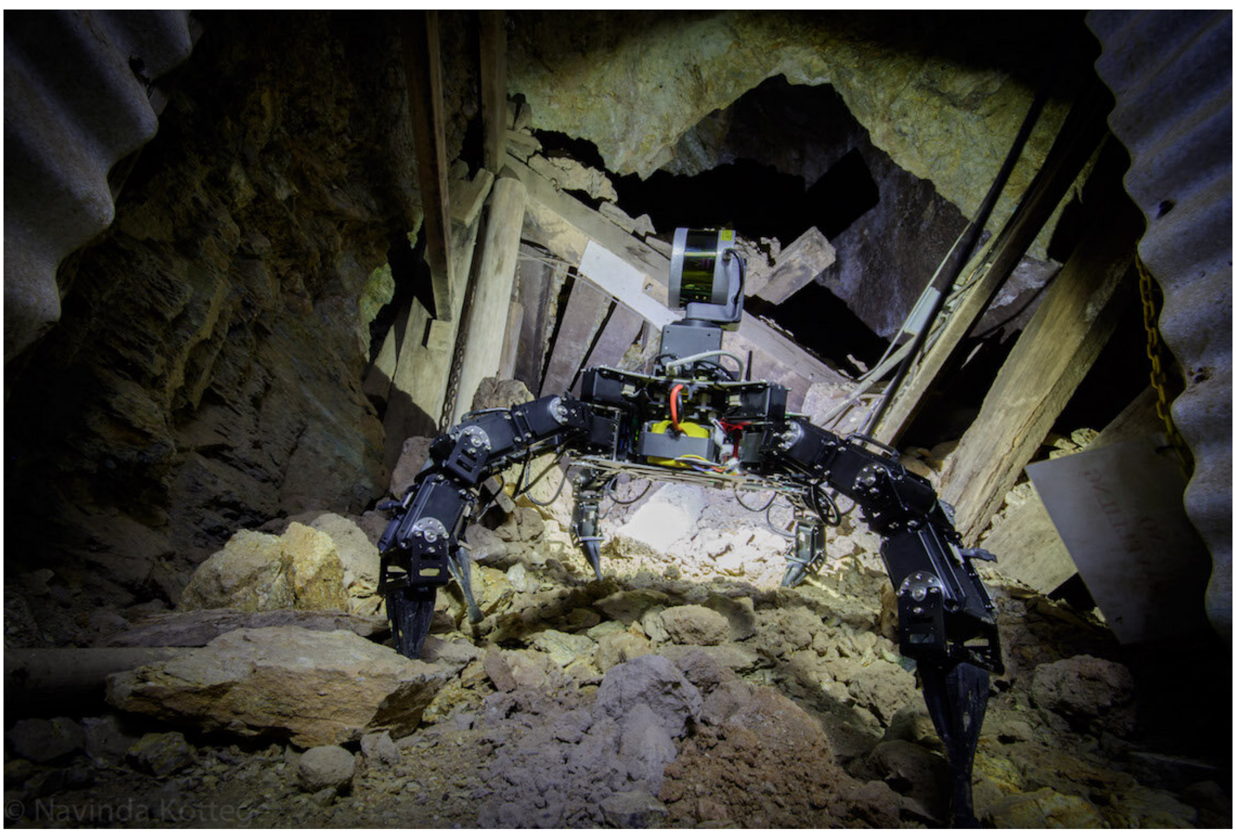
"We have been doing legged robot research and developing our own legged robots for the past eight years," Navinda Kottege, lead researcher of the team that carried out the study, told TechXplore. "These multi-legged robots have many degrees of freedom (e.g., Weaver has 30 joints) allowing them to have many different postures when they walk. When we deployed our robots in complex confined environments such as underground mines, ceiling cavities or underfloor areas, we realised that they need to change their leg and body configuration (i.e. posture) to squeeze through narrow gaps, walk over high obstacles or crawl under low overhangs. This requirement is what prompted this piece of research."

Credit: Kottege et al.

The recent study carried out by Kottege and his colleagues takes inspiration from soft robotics, proposing a deformable bounding box abstraction of the robot model, combined with mapping and planning strategies. For mapping, the researchers used robot-centric multi-elevation maps generated via distance sensors mounted on the robot. For path planning, they used a trajectory optimization algorithm called CHOMP, which can create smooth trajectories while avoiding obstacles.

"The sensors mounted on the robot, in this instance a stereo camera based 3D sensor, provide a 3D point cloud of the surrounding environment," Kottege said. "Essentially, these are a series of distances from the robot to various objects in its surrounding environment. This geometric information is converted in to a multi-elevation map where floors and ceilings are identified, informing the robot of the space it needs to walk through."

The approach devised by Kottege and his colleagues models a robot as a deformable bounding box, which can be deformed within its specific joint limits, in order to fit through narrow spaces. The researchers also developed a series of algorithms that allow this deformed bounding box representation to map to a set of joint angles, which are then fed to the robot, allowing it to autonomously adapt its posture as it navigates through the confined spaces.



Credit: Kottege et al.

"The methods that we have developed are not bound to a particular sensor or a particular legged robot," Kottege explained. "These findings can be applied to data coming from any sensor that gives a 3D point cloud of the environment (e.g. Lidars, ToF cameras) and any robot with enough degrees of freedom allowing it to be modelled as a deformable bounding box. Applying these results can give future robots the ability to effectively adapt their postures in real-world applications such as search and rescue in a collapsed mine or in the aftermath of an earthquake to get through difficult and complex confined spaces and reach survivors in time."

The researchers implemented and evaluated their proposed method both in simulations and on CSIRO's hexapod robot Weaver, which is 33 centimeters tall and 82 centimeters wide, when walking normally. They were able to attain navigation under 25 centimeters of overhanging obstacles, through 70 centimeters-wide gaps and over 22 centimeters-high obstacles, in both artificial testing spaces and realistic environments, such as a subterranean mining tunnel. In the future, their model could be applied to legged robots that need to operate in mines, construction sites, damaged buildings, and other challenging environments.

"We will now continue to work on developing robust and efficient legged robots capable of operating in complex real-world environments targeting applications such as search and rescue, especially in subterranean environments with no GPS coverage," Kottege said. "This is an area of work rich in research problems ranging from mechanism design, robot sensing and perception to localisation and navigation to name a few."

More information: Walking posture adaptation for legged robot navigation in confined spaces. arXiv:1901.10863 [cs.RO]. arxiv.org/abs/1901.10863

Citation: A model for posture adaptation of legged robots while navigating confined spaces (2019, February 14) retrieved 27 April 2024 from https://techxplore.com/news/2019-02-posture-legged-robots-confined-spaces.html