Transformable wheel-track mobile robot

Participants: Ruihan Gao[ab],Baichuan Zhang[a], Zhongyuan Niu[a], Yan Hui[a]

Faculty sponsor's: Chin-Hsing Kuo[b], Weigang Wen[a], Yanan Yao[a]

E-mail address: 23222033@bjtu.edu.cn

postal address: No.3, Shangyuan Village,Beijing,China 100044

Institution: [a]Beijing jiaotong University, [b]University of Wollongong

Category: Undergraduate

Date: May 15th, 2024

Final Written Report

—— project description

Background

In contemporary times, propelled by the swift evolution of science and technology, the conceptualization and realization of mobile robotic systems have undergone substantial advancements. Leveraging mobile robots to supplant human intervention in certain tasks not only enhances temporal efficiency but also mitigates the risk of human injury. However, the exigencies imposed upon mobile robots have transitioned from rudimentary task execution towards the imperative of autonomous environmental adaptation and the resolution of intricate challenges. Conventional mobile robotic platforms, exemplified by wheeled or tracked configurations, manifest limitations when confronted with complex topographies or demanding operational scenarios. In pursuit of innovative solutions, researchers are actively engaged in the development of sophisticated mobile robotic architectures, among which transformable robots emerge as a promising avenue of exploration.

Functional description

Essentially, as a subclass of mobile robots, transformable robots possess the inherent capacity to fulfill the fundamental functionalities of mobility and maneuverability. However, unlike conventional mobile robots optimized for specific terrains, our designed transformable robot aims to exhibit exceptional adaptability within complex terrains. For instance, in scenarios characterized by varied topographies comprising both flat expanses and rugged terrain interspersed with obstacles, conventional mobile robots may encounter operational impasses and mobility constraints. By contrast, the envisaged transformable robot is envisaged to navigate such challenging environments adeptly. Specifically, it transitions seamlessly between diverse locomotion modes tailored to the prevailing terrain conditions. In flat terrain, the robot operates optimally in wheel-mode, swiftly traversing the terrain. In rugged terrain, it seamlessly switches to track-mode, ensuring robust cross-country performance. Moreover, when confronted with obstacles impeding traversal, the robot employs a leg-like mechanism to surmount barriers effectively. In essence, the transformable capabilities of our robot facilitate versatile terrain adaptation, enabling efficient navigation through complex environments by harnessing agile locomotion mechanisms and potent propulsion systems. Thus, the overarching objective of our transformable robot design is to realize optimal performance across diverse terrains through adaptive morphological transformations.

Features

The primary focus of our robotic system lies in its wheel mechanism, which distinguishes it as a "transformable robot". This designation stems from the wheels' ability to adapt to various configurations through transformation. The foundational elements of the wheels comprise the wheel frame, connecting rods, gears, and racks. In its wheel mode, the connecting rods support the frame in a circular formation. However, in track and leg modes, the connecting rods retract, driven by the gears, while the frame assumes an elliptical shape. This transformation is depicted in Fig.1(a) and Fig.1(b). Within the wheel structure, a set of belt wheels and belts facilitate additional functionalities, such as track propulsion. In wheel and leg modes, the belt wheel remains stationary, maintaining the static position of the track. Conversely, in track mode, the rotation of the belt wheel propels the track's movement. The configuration of the belt and belt wheel is illustrated in Fig.2.

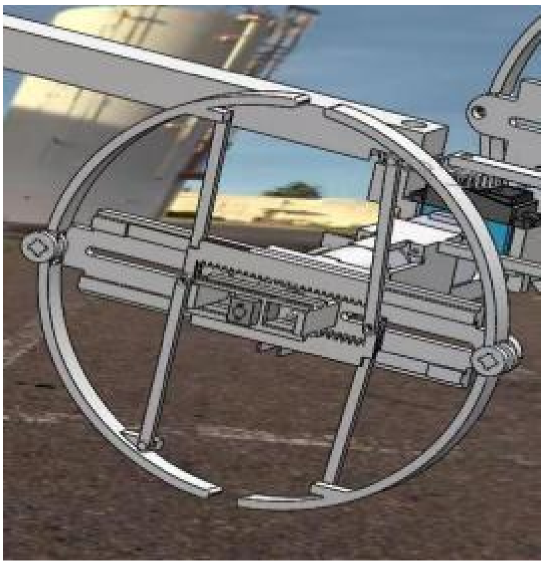

Fig.1(a) circle wheel (wheel-mode)

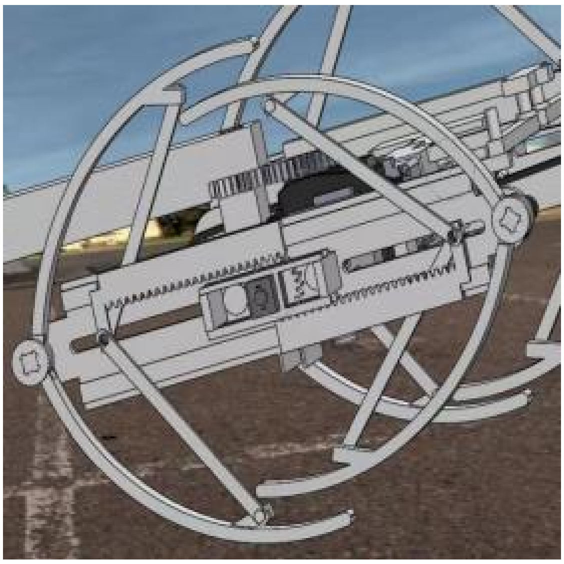

Fig.1(b) ellipse wheel (track-mode)

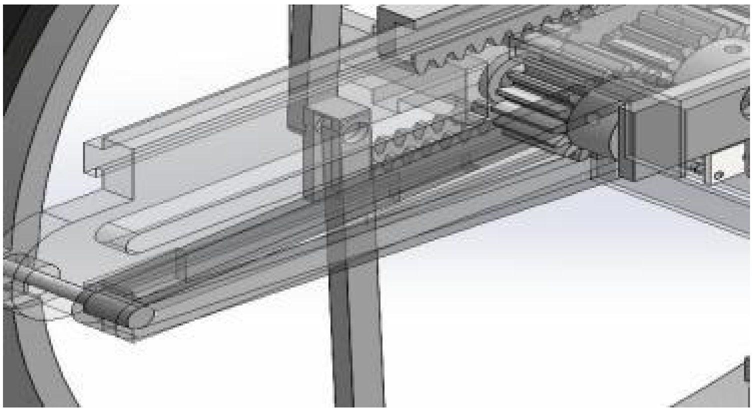

Fig.2 the detailed drawing of belt and belt wheel

Interpretation of mechanical principles

Track-mode:

The axis lever is close to the motor frame, and the key of the motor output shaft only contacts the intermediate gear. The gear locking rod is close to the body. The intermediate gear drives the rotation of the two side belt gears, which in turn drives the rotation of the track wheel through the belt transmission, causing the track to move.

Wheel-Mode:

The shaft lever is positioned in the frontwith the key of the motor outputs haft only engaging with the key slot on the wheel frame. The gear lockingr od is close to the wheel frame, with its upper part in contact with the two side belt gears. The track remains stationary relative to the wheel frame, while the motor drives the overall deformation wheel movement.

The schematic diagram of mechanism and the table shown below. Fig.3(a) is wheel-mode, Fig.3(b) is track-mode, Fig.3(c) is axle and wheel frame, Fig.3(d) is belt wheel and track and Table.1 indicate the relationship between each input source and mechanism.

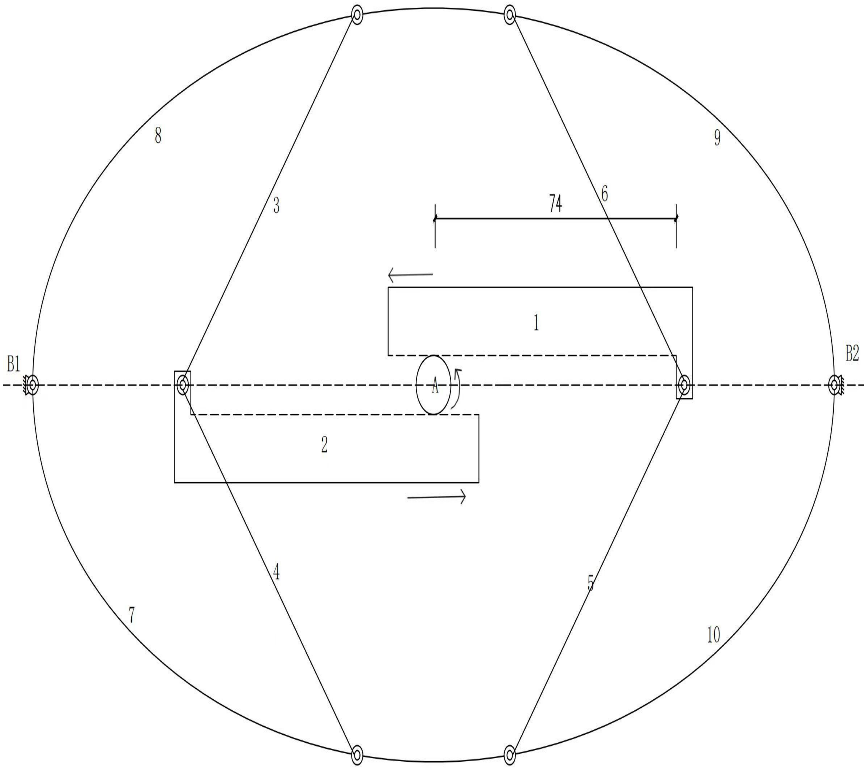

Fig.3(a) wheel-mode

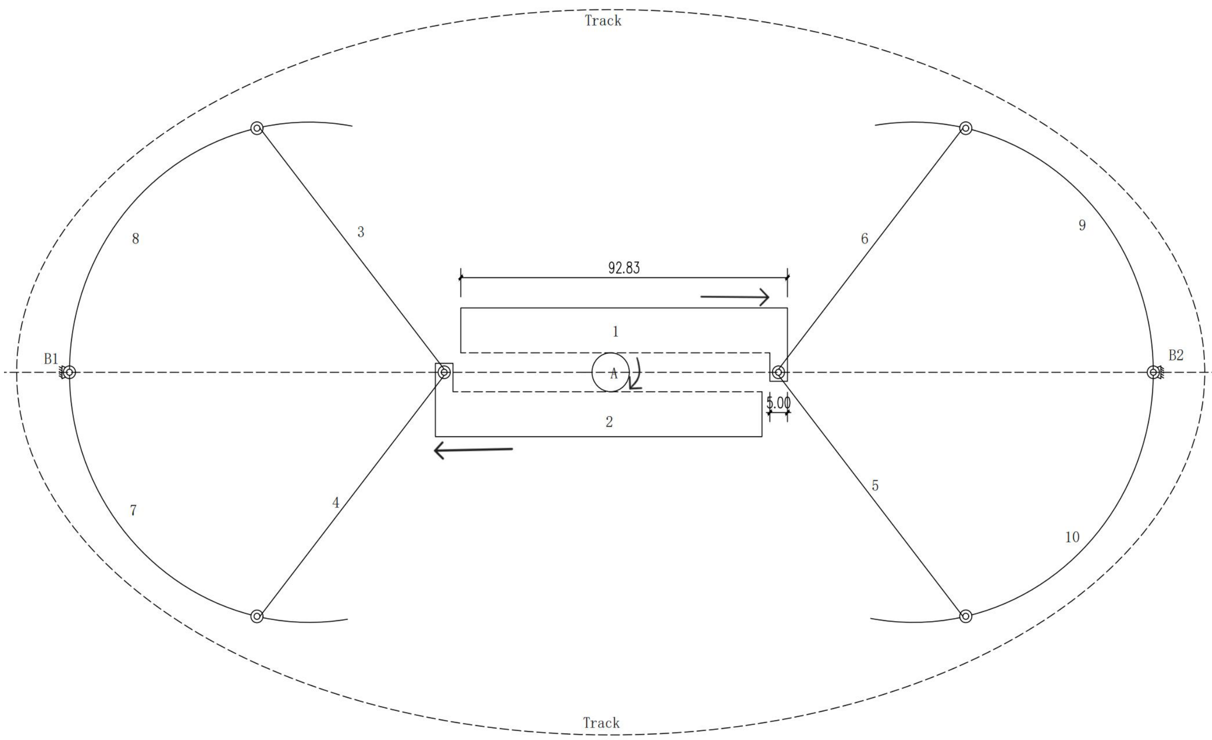

Fig.3(b) track-mode

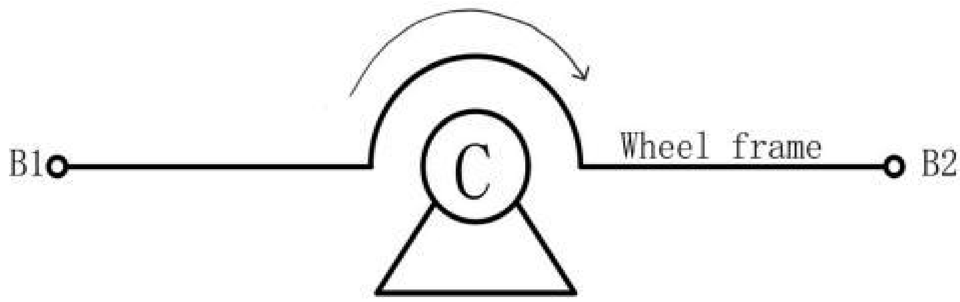

Fig.3(c) the axle and the wheel frame

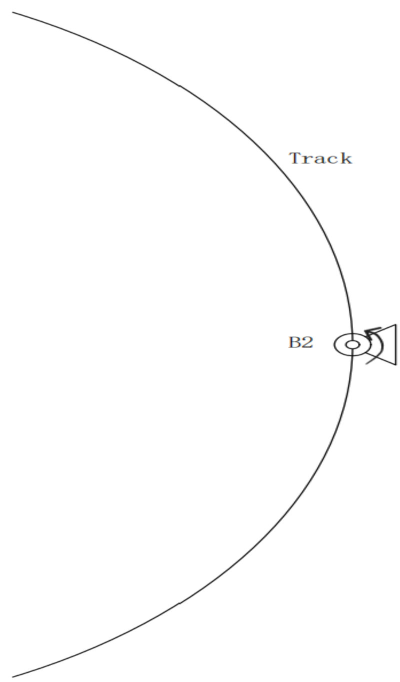

Fig.3(d) the belt wheel and the track

Table.1 the relationship between each input source and mechanism.

Mode	Input	Moving parts	Static parts
Wheel-mode	axle C	whole wheel	racks 1,2 rods 3,4,5,6 frames 7,8,9,10 track belt belt wheel
Track-mode	belt wheel B1 and B2	track belt belt wheel	racks 1,2 rods 3,4,5,6 frames 7,8,9,10
Wheel-mode transforms to Track-mode	gear C	racks 1,2 rods 3,4,5,6 frames 7,8,9,10	track belt belt wheel

Procedures used to design

1. Solidworks2024 used to design the structure of robot and draw the appearance of robot, shown in Fig.4.

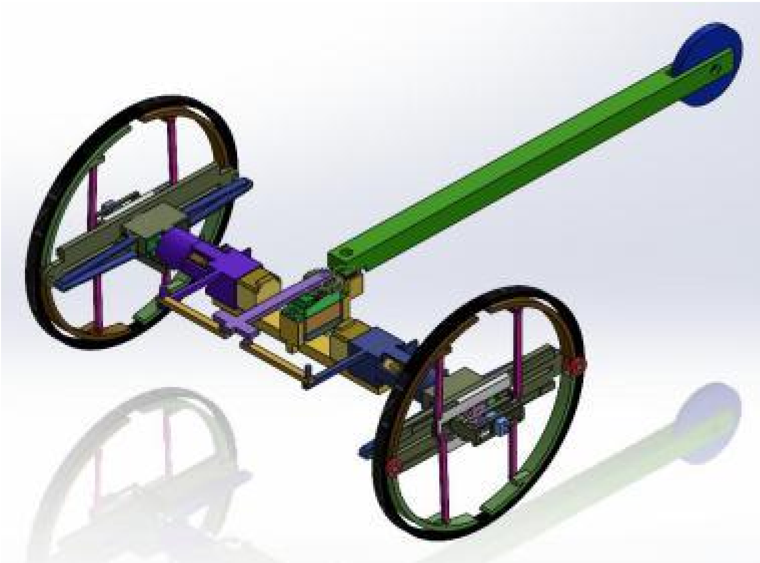

Fig.4 The design based on Soildworks2024

2. CAD2024 used to draw the schematic diagram of mechanism.

Benefits and possible applications

Based on above, our transformable robot boasts the intrinsic capability to dynamically adjust its operational mode in accordance with the exigencies imposed by diverse terrains. This characteristic assumes paramount significance in negotiating complex terrains, where conventional robots typically falter due to their specialization for specific terrain types, thereby manifesting optimal performance solely within restricted contexts. Consequently, conventional operational paradigms necessitate the deployment of a multitude of specialized robots in tandem to address multifaceted missions effectively. For instance, traditional methodologies rely on wheeled vehicles for cooperative freight transportation across intricate terrains, albeit at the expense of inefficiency and heightened resource consumption. Conversely, the transformable potential of our robot enables the seamless execution of such missions with remarkable efficiency, provided the requisite technological maturity is attained.

Leveraging its unparalleled adaptive prowess and robust performance metrics, the transformable robot delineates its superiority across diverse terrains such as deserts, marshy grounds, undulating landscapes, and dilapidated environs. Consequently, its application spectrum spans a gamut of domains including military reconnaissance, disaster relief endeavors, and logistical operations. For instance, in post-earthquake rescue missions, the transformable robot exhibits unparalleled agility in negotiating the tumultuous and unpredictable terrain of rubble-strewn locales, thereby augmenting the efficacy of search-and-rescue operations manifold. Moreover, in domains pertaining to medical assistance and domestic service, the transformable capabilities of the robot render it adept at furnishing efficient and flexible services, ranging from medication delivery in healthcare facilities to household chore assistance in domestic settings.Furthermore, the transformable trajectory of the robot extends beyond terrestrial confines, with envisaged technological advancements poised to equip it with aeronautical and nautical functionalities, thereby conferring upon it an all-terrain demeanor.

In addition to stand-alone robotic designs, the utilization of transformable robots within the domain of "robot collectives" presents significant prospects for advancement. Through the deployment of corresponding control algorithms across multipl transformable robots, coordinated intelligent behaviors can be achieved within the collective. This approach not only enhances task efficiency but also fortifies the overall system against the challenges posed by intricate environments and tasks, showcasing heightened robustness. In the broader scope, the integration of transformable robot holds pivotal implications for enhancing human life quality and productivity. Its applicability spans critical sectors including industrial automation, intelligent transportation, and environmental conservation. In essence, transformable robots are poised to usher in transformable shifts within the realm of robotics. Consequently, the imperative lies in amalgamating transformable robots with other forefront technologies, serving as a beacon towards a promising future and aligning with the overarching trajectory of human development.

Acknowledge

- The professors who offer us many practical recommendations.
- The students who make contributions to this project.
- The company which assisted us to make 3D-Printing mechanisms.
- The robot laboratory which offer us technological support.