Abstract

In this doctoral thesis, a method for the synthesis and analysis of a multi-directional omnitrack robot, featuring fully overlapping tracks, is presented. Omnitrack robots are vehicles equipped with specially modified tracked drive systems. Additional rolling elements (either driven or passive) are mounted on individual track links, enabling movement in directions other than the vehicle's primary axis.

The introduction of this thesis characterizes the classification of mobile robots based on their applications, modes of locomotion, and types of chassis. Existing variants of omnitrack chassis are identified. The current state of knowledge regarding omnitrack vehicles is analyzed, and research gaps are identified. Based on this, the primary objective of the study is determined, with additional aim to acquire new knowledge.

The initial part of the thesis contains a description of considerations regarding the kinematic model of the omnitrack vehicle module, which comprises two independently driven tracked systems. Equations of motion for a single module are presented, and relationships are derived to determine the direction and speed of the body movement relative to the ground given the linear speeds of individual tracks. The construction of a numerical model is then described, which was used to conduct a series of dynamic simulations The simulation results are compared with data obtained from the kinematic model.

The next part of the thesis describes the design and construction of the OMP2024_1 omnitrack robot prototype. Its focus is on experimental studies of the OMP2024_1 driving parameters, confirming the occurrence of the curvature of the trajectory phenomenon, as described in the literature on omnitrack vehicles. This phenomenon involves the gradual, unintended change in the angular orientation of the omnitrack vehicle that occurs during its movement. Based on the research results, an algorithm for static direction correction was proposed, which counteracts this phenomenon. Further studies describe verifying the positive impact of the static direction correction algorithm on the accuracy of reproducing the intended movement trajectory.

The subsequent section presents studies conducted on the rolling resistance of a free-rolling element. These studies included examining the shape of the roller, type of substrate, external load, orientation angle, and movement speed on the distribution of friction forces between the ground and the free-rolling element. Based on this knowledge, the full-scale OMP2024_2 omnitrack robot was designed. The design methodology, construction assumptions, and building process are described. This vehicle was used to conduct empirical driving tests of the omnitrack robot. The study presents dynamic direction correction algorithm, which counteracts the undesired change of assumed angular orientation of the vehicle body. Additionally, modules enabling obstacle detection, human detection, and response to obstacles on the predetermined movement trajectory, based on data provided by the vision system, which is part of the OMP2024_2 vehicle, are presented.

The final section includes a summary with conclusions, as well as a description of currently ongoing and planned research.