Servosila Engineer Crawler Robot Modelling in Webots Simulator

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***Abstract*— In robotics, a simulation is an essential stage on a way of transferring a theoretical idea into a real world application. Since each popular simulator for robotics has particular advantages and shortcomings, it could be beneficial to simulate an algorithm behavior in several modelled instances prior to its integration into a real robot control system. This paper presents a new model of the Russian crawler type robot Servosila Engineer for the Webots simulator, which extends our previous work within the Gazebo simulator. The robot control is implemented with Robot Operating System (ROS). Webots-based simulations were reproduced using our mature Servosila Engineer robot model in Gazebo and validated within real random step environments of the laboratory.**

***Index Terms*— mobile robot, crawler robot, Servosila Engineer, urban search and rescue, Webots, ROS, simulation, modelling**

I. Introduction

Robotics is one of the most fast growing fields in nowadays. Robots are broadly applied for everyday tasks such as house cleaning and infrastructure inspection [1], manufacturing [2] and security [3], entertainment and advertisement [4]. One of the most important applications of mobile robots is urban search and rescue (USAR, [5]), which covers reconnaissance [6], human assistance [7] and interaction [8] in extreme environments. The USAR, as well as other applications, require robot design [9] and modelling [10], exhaustive verification and validation in real world scenarios [11, 12]. Validation of USAR robots in real disasters of terrorist attacks [13] and Fukushima nuclear power plant accident [14] emphasized the significance of a proper simulation prior to moving into a dangerous environment for a complicated mission within potentially radioactive or chemical contamination [15]. Since it might be a difficult task to reproduce physical instances of ruined buildings or to validate algorithms and approaches in flooded or contaminated environments, simulation is a viable option for preliminary testing that allows fast and easy setup as well as safe and repeatable virtual experiments.

This paper presents a new model of the Russian crawler type robot Servosila Engineer for the Webots simulator, which extends our previous work within the Gazebo simulator. The robot control is implemented with Robot Operating System (ROS), and Webots-based simulations were reproduced using our mature Servosila Engineer robot model in Gazebo [16] and validated within real random step environments [17] of the laboratory.

II. Related Work

A number of papers on creating and improving a simulation model of Servosila Engineer crawler robot in the Gazebo simulator (Fig. 1) were previously presented by our research group [16, 18]. The created model is equipped with all on-board sensors of the real robot, has a properly working navigation stack and demonstrated good performance in virtual experiments that were conducted in multiple researches, e.g., [19]. The most critical issue of using the proposed Gazebo model was caused by a real-time factor (RTF) of the simulation. RTF presents a correlation of the time in simulation to the real time. For example, if in a simulation it takes ten seconds

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to compute a one second (real world) action, the RTF is 0.1. The less RTF value is the slower and less efficient is a simulation. The issue with a low RTF appears as a result of an absence of a standard solution for simulating tracks in the Gazebo, which forces research teams to construct original solutions, e.g., [20]. One of the popular solutions in the Gazebo is simulating tracks with the simulated invisible pseudo-wheels [21]. For covering tracks and providing a good traversability of environment obstacles, a simulation usually requires a large amount of pseudo-wheels, which significantly harms the RTF; e.g., using of over two hundred pseudo-wheels in Servosila Engineer decreased the RTF to at most 0.1 while a comfortable to a user RTF should be at least 0.3 [22].

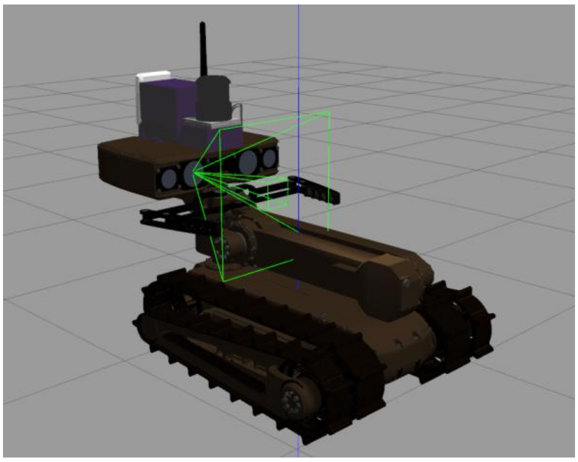

Figure 1. Servosila engineer model in the Gazebo simulator.

While we keep improving the Gazebo model of the robot in order to overcome the difficulties with the RTF (which has a lower influence with high performance computers), it was decided to implement the model within another simulator as well. We selected Webots [23] that has a standard and efficient solution for a track simulation, which does not demonstrate a heavy effect on the RTF.

III. System Setup

A. Servosila Engineer Crawler Robot

Servosila Engineer crawler robot is produced by the Russian company Servosila [24]. The dust and waterproof robot with radiation-hardened electronics is equipped with main tracks and additional frontal flippers (Fig. 2), which makes it efficient in open-air missions, varying weather conditions, uneven terrains traversal and working in extreme situations. Four cameras in the head of the robot contain a stereo pair that allows obtaining depth information in front of the robot, a frontal zoom camera and a single rear camera. A bright torch in the robot head, which is located between the frontal stereo pair cameras, allows teleoperation in low light conditions and night open-air operations.

Servosila Engineer has a variety of configurations that make it a good research and education platform. The robot has a relatively light weight of about twenty kilograms and could be carried around by a single person. Table I demonstrates weight characteristics of the robot and its parts that were used for creating the Webots simulation model.

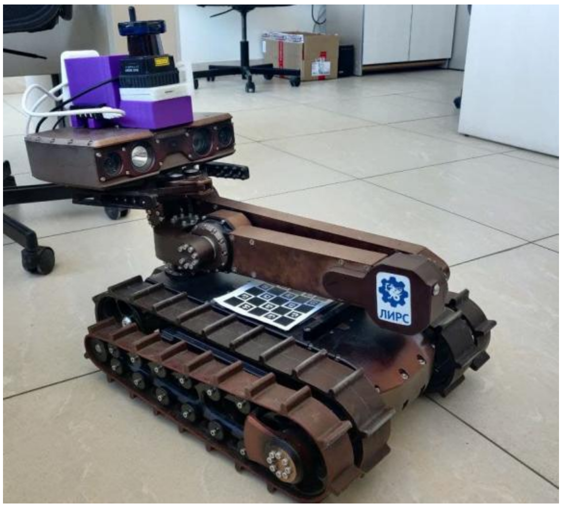

Figure 2. Servosila engineer robot, courtesy of Servosila company.

TABLE I. Servosila Engineer Robot Weight Data.

Equipment	Weight
Robot chassis with two main tracks, two traction motors and motor control electronics	8.8 kg
Two-segment 3 DoF arm with three servos	4.4 kg
On-board control and power systems	2.1 kg
Sealed connector for external payloads or external computer	0.1 kg
LiFePo battery	3.7 kg

B. Simulation Environment in ROS/Webots

Webots [23, 25] is a popular platform that attracts researches by its simplicity. It is an open-source multi-platform desktop application being widely employed for robot simulation [26, 27]. It also supports ROS and allows to control the robot using classical ROS-services.

Using ROS [28] allows creating a unified control for virtual models and the real robot itself, which enables running virtual experiments and their (almost) simultaneous validation with real world and real-time experiments [29]. Another useful feature of ROS is the ability to communicate with other robots that is required in multiple tasks for swarms, homogeneous and heterogeneous robotic teams.

IV. Creating a Virtual Model

Our broad experience with Gazebo simulator revealed a number of consistent problems, which are successfully solved by Webots simulator. For example, any change of an environment scene in a run-time in Gazebo requires to reload the updated environment. When a robot model is constructed in Gazebo the data is saved as a URDF configuration file. Construction of a model in Webots is executed in a graphical interface. Naturally, it appears that moving manually parts of the model in a viewport of Webots (in order to connect the parts) is more comfortable and precise than changing values in the

Gazebo URDF configuration file, which requires reloading the entire simulation every time after the change. Models in Gazebo could be used in "dae" format, while Webots requires a conversion into "obj" format. Using "obj" format means separating a texture from a model. In Gazebo simulator instead setting up environment variables for object's material, textures are set inside model files; in Webots all textures could be set simultaneously at a run-time as an environment variable, which is easier and faster. The Webots model of the Servosila Engineer robot is demonstrated in Fig. 3.

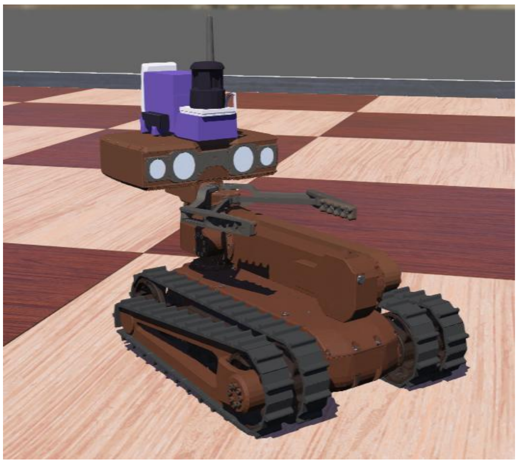

Figure 3. Simulation model of Servosila Engineer in Webots simulator.

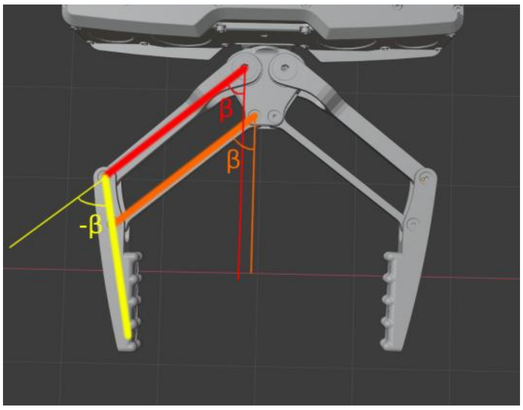

Figure 4. Scheme of moving the gripper by angle β.

In terms of modelling and control, one of the most tricky parts of the Servosila Engineer model is its end-effector (a gripper). A motion scheme of the gripper is demonstrated in Fig.4. Opening or closing the gripper for some angle β requires to move simultaneously all six parts of the gripper. The so-called mimic joints were employed for the gripper modelling in Gazebo [18], but Webots simulator does not support mimic joints construction. In Webots we implemented the gripper as a ROS-node that listens a topic with commands (to the gripper) and sends six commands directly to each part of the gripper.

V. Track Simulation

Creating a model for a crawler-type robot is tricky for simulators. In the past decade for Gazebo there were proposed several approaches (e.g., ROS-based package for tracks modelling *Gazebo-tracks* [29]). The most popular solution is a replacement of tracks with a large number of simulated invisible pseudo-wheels, which was previously mentioned in Section II. The pseudo-wheels approach typically considers hundreds of invisible wheels, which unfortunately decrease the RTF to unacceptably low values. As for Webots, it provides a track simulation within its standard assets and thus allows to decrease a model complexity drastically in terms of the model parts' number. Since all independent parts are constantly validated for collisions in the run-time, reducing the number of such parts significantly increases RTF. Table 2 demonstrates a comparison of the Webots model of Servosila Engineer with its Gazebo model: decreasing a number of the model's elements in about 20 times resulted in 10 times increase of the RTF.

Simulating a track with pseudo-wheels approach has other disadvantages as well. One of them is a presence of a small gap between two adjacent wheels. Often these gaps may cause a jamming of a robot while operating within an uneven terrain if a sharp obstacle edge or a pike under the simulated track appears in a gap between pseudo-wheels, which is a typical situation for climbing stairs. Since in Webots a track is a solid continuous body, such sticking within an uneven terrain does not occur.

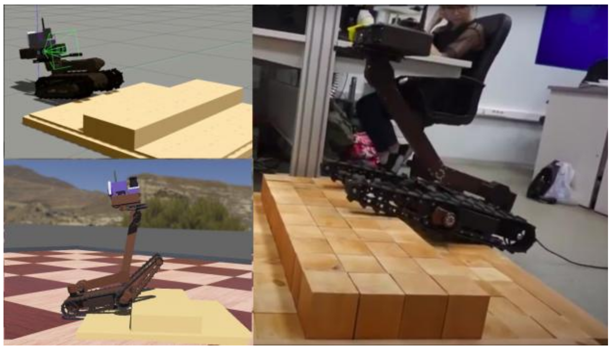

Figure 5. Virtual experiments within a simple horizontal barrier of the random step environment (RSE) in Gazebo (top left) and Webots (bottom left) simulators, and a real world validation experiment (right).

To compare our Webots and Gazebo models, virtual experiments were performed using the same configuration of a random step environment (RSE). We constructed a simple horizontal RSE barrier of a single-step height in Webots, Gazebo and real world environments (Fig. 5) and the corresponding models of Servosila Engineer and the real robot crossed the barrier in a teleoperated mode. It is worth mentioning that simulating this experiment in Gazebo was extremely time consuming due to the low RTF (Table II). Experiments were also performed in a number of more complicated configuration of the RSE, e.g., the one demonstrated in Fig. 6. The Gazebo model, in addition to the low RTF, was stuck several times on the edges of RSE blocks when the aforementioned pseudo-wheels gap problem was encountered. At the same time, the Webots model successfully traversed the RSEs without jamming. Additionally, we validated the Webots model behavior with several built-in smooth terrains of Webots (Fig. 7).

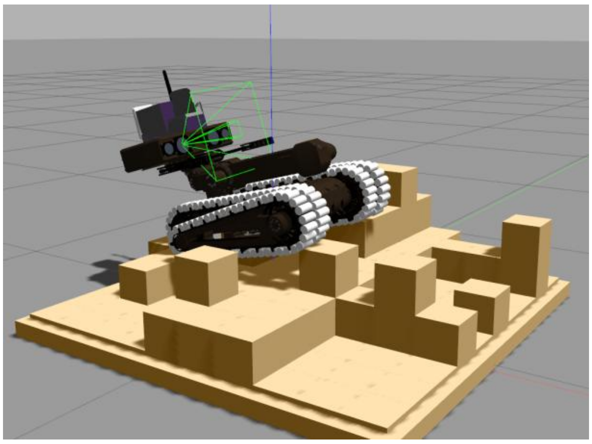

Figure 6. RSE experiments in Gazebo.

Figure 7. Uneven terrain experiments in Webots.

TABLE II. ENGINEER SIMULATION MODEL COMPLEXITY

Parameter	Gazebo	Webots
Number of elements	221	11
Real time factor (RTF)	0.1 ~ 0.2	0.95~ 1

VI. CONCLUSIONS

This paper presented a new model of the Russian crawler type robot Servosila Engineer for the Webots simulator, which extended our previous work within the Gazebo simulator. The robot control was implemented with Robot Operating System (ROS). Webots-based simulations were reproduced using our mature Servosila Engineer robot model in Gazebo and validated within real random step environments of the laboratory. The main new important features of the presented Webots model are its ROS-control, small number of the model's elements (20 times less than in the corresponding Gazebo model) and an extraordinary high level of the real-time factor (RTF) that stayed between 0.95 and 1 in all virtual experiments, while the currently implemented Gazebo model demonstrated the RTF between 0.1 to 0.2 within the same settings, which is not enough for a comfortable real-time simulation.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

AD conducted the research, modelling and programming; RL conducted programming; EM supervised the research and wrote the paper; YB validated the models; MS performed existing solutions analysis; RM performed comparative analysis; all authors had approved the final version.

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