2020 Fourth IEEE International Conference on Robotic Computing (IRC)

Planning and Evaluation of Robotic Solutions in a Logistic Line Through Augmented Reality

Gabriele Bolano Arne Roennau Ruediger Dillmann
Department of Interactive Diagnosis and Service Systems (IDS),
FZI Research Center for Information Technology, Karlsruhe, Germany
{bolano, roennau, dillmann}@fzi.de

***Abstract*—The planning and evaluation of robotics solutions in logistic environments is a time consuming process. It usually requires to plan on paper or with 2D CAD software the setup and flow of the parts in a line, with the need to buy and set up expensive equipment in order to test and validate the planned solution. Augmented Reality (AR) is a promising technology for these applications. The required equipment and parts can be simulated in order to evaluate the system beforehand, computing the resulting performance information automatically. The simulated hardware can be superimposed at the desired position in the real scenario, giving the user a more precise information on how the components in the setup will behave. In this work we propose an AR system to plan and configure a line consisting of a robot and a conveyor belt. The proposed system architecture allows to adapt the behavior of the existing hardware components accordingly to the changes introduced in the simulation. The performances of the picking task are computed by the system and visualized to the user, as well as the simulated objects. A GUI allows the worker to change and adjust the speed of the robotics components and the position and flow of the parts. An additional robot can be placed and visualized in order to evaluate the improvements in the line performance deploying additional equipment.**

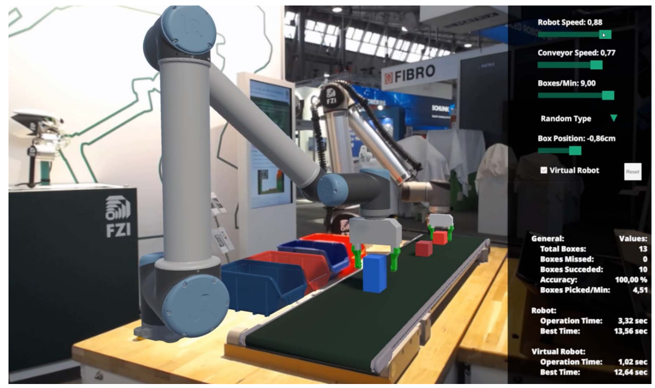

Fig. 1: The augmented representation of the planned line. The virtual robot and parts are displayed to the user, who can modify the parameters of the simulation through a GUI to get the resulting performance of the line.

I. Introduction

Robotics solutions for logistic applications have the advantage to automate slow and repetitive process, with a consequent improvement in throughput and cycle time. The planning of these solutions is a time consuming process and the achievement of realistic performance estimations is a challenging task. Simulation environments allow the representation of complex systems without the need to involve any hardware and without the effort and costs needed to set up the line in the real world.

AR is a promising technology which allows the visualization of virtual components superimposed on real world objects. The simulation and visualization of the parts flow can ease the planning phase and the current configuration could be adapted and optimized without the need of time consuming modification in the hardware configuration. The communication of the existing hardware setup with the simulation system, allows to apply the changes directly to the real hardware in an intuitive way without the need to a reprogramming phase and programming experts.

In this work we propose a system that enables the planning and evaluation of a robotic solution in a logistic line. The use of a simulation environment, allows the user to easily change the relevant parameters of the process using a GUI. The simulated environment and the flow of the parts are represented in AR, superimposing the virtual objects on the actual setup. This allows the worker to have a better understanding on the impact that the changes might have on the real system. We provided a system architecture to enable the online control and adaptation of the real robotic components already in the setup, accordingly to the changes introduced in the simulation environment. The online computation of performance indicators, as cycle time and throughput of the line, gives the user an immediate feedback about the impact of the changes applied in the simulation.

II. Related Work

Simulation tools are nowadays used for many applications. As an example, simulation environments are extensively used in robotics for programming. This allows the teaching and visualization of the robot trajectories in a safe way and without the need to work on the real setup [1].

Virtual Reality (VR) is a technology that in the last years has been deployed for this kind of robotics applications [2]. VR is a powerful tool to display a completed simulated scenario, offering the user an immersive experience. However, the information displayed in the virtual environment could be perceived differently when applied in the real world. That is the main reason why AR is also spreading as a powerful and interesting technology for many robotics applications. AR allows the visualization of virtual objects and information in the real world, attaching 2D or 3D components at the desired

978-1-7281-5237-0/20/$31.00 ©2020 IEEE
DOI 10.1109/IRC.2020.00075

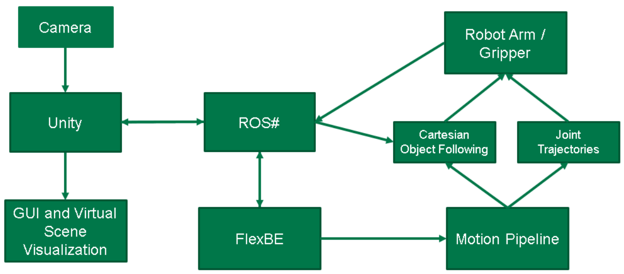

Fig. 2: Overview of the system software architecture and communication between the components.

position and superimposing them in the real environment [3]. In the work of Rohacz et al. [4], the use of AR as potential tool to support intralogistic planning in the automotive industry is investigated. The study showed that in literature there is a lack of scientific research for intralogistic planning and the authors proposed an AR application to plan carries and shelves. Reif et al. pointed out that production and logistic lines require continuous adaptations and even rebuilding [5]. For this reason is fundamental to deploy a planning tool to generate realistic models before the actual realization. The authors highlight a possible use of VR and AR to developed new intuitive and efficient methods for this task.

III. Approach

The system proposed in this paper is an AR-application which enables the user to plan in simulation the behavior of a robotic system in a logistic line. The software architecture deployed allows to simulate the needed components, adapting the behavior of the real setup accordingly to that. In this way the user can simulate different configurations of the line, examining the behavior of the already installed hardware. The AR-application developed is mainly implemented in Unity [6], while ROS (Robotics Operation System) [7] has been used for the control of the robotic components. The communication between Unity and ROS has been implemented using the open source software library ROS# [8]. The overall architecture of the system is depicted in Fig. 2.

In the system developed, it is also possible to simulate only the parts moving on a conveyor belt, having the real robot in the actual hardware setup reacting accordingly to the changes set in the application GUI. The possibility to include virtual robots to the scene, allows the user to further evaluate the performances of the line deploying additional equipment, evaluating the best position for it in terms of reachability and good account of results.

IV. Evaluation

The system has been deployed on a setup which included a conveyor belt, a 6-DOF robotic arm and a gripper. A camera in a fixed position provided the live image stream of the current setup of interest. A touch screen positioned in front of the setup was added to visualize to the user the augmented scenario together with the GUI. In this way the relevant parameters of the line could be easily changed and a simulated robot could be added in the setup. For every modification in the input parameters, the resulting performance of the line were automatically computed and visualized as well.

In order to evaluate the intuitiveness and ease of use of the system, we presented the application scenario developed at the Motek 2019 fair in Stuttgart, where people had the opportunity to interact with the setup in order to change the provided parameters and get to know the consequent performance results.

V. Conclusions

The AR-based system proposed in this work enables an easy way to plan and validate robotic solutions in a logistic line. The computation and visualization of important production information, such as the cycle time and throughput, allow the user to have an immediate feedback about the resulting performance of the line. If a robot is already operating in the real setup, the proposed architecture enable it to adapt to the simulated objects and parameters selected. The possibility to add virtual robots in the simulation, allows the user to plan and validate the use of new robotic solutions without the need to buy expensive equipment beforehand in order to test it.

The system developed could be improved adding more flexibility in the definition of the virtual objects and expanding the library of hardware that can be deployed in the simulation. The use of augmented reality headset, could make the representation of the virtual objects more effective, without the need to look at monitors or handheld devices.

Acknowledgment

The authors acknowledge the financial support by the Federal Ministry of Education and Research (BMBF) of Germany in the framework of Sim2Log VR (project number 16SV8191). The Unity development was supported by TruPhysics GmbH.

References

[1] J. Guhl and S. T. Nguyen, “Concept and Architecture for Programming Industrial Robots using Augmented Reality with Mobile Devices like Microsoft HoloLens,” pp. 2–5, 2017.

[2] J. I. Lipton, A. J. Fay, and D. Rus, “Baxter's homunculus: Virtual reality spaces for teleoperation in manufacturing,” *IEEE Robotics and Automation Letters*, vol. 3, no. 1, pp. 179–186, Jan 2018.

[3] S. K. Ong, A. W. W. Yew, N. K. Thanigaivel, and A. Y. C. Nee, “Augmented reality-assisted robot programming system for industrial applications,” *Robotics and Computer Integrated Manufacturing*, vol. 61, no. January 2019, p. 101820, 2020.

[4] A. Rohacz and S. Strassburger, “Augmented reality in intralogistics planning of the automotive industry : State of the art and practical recommendations for applications,” in *2019 IEEE 6th International Conference on Industrial Engineering and Applications (ICIEA)*, April 2019, pp. 203–208.

[5] R. Reif and D. Walch, “Augmented & Virtual Reality applications in the field of logistics,” *The Visual Computer*, vol. 24, no. 11, pp. 987–994, nov 2008.

[6] Unity, 2019, https://unity.com.

[7] M. Quigley, K. Conley, B. P. Gerkey, J. Faust, T. Foote, J. Leibs, R. Wheeler, and A. Y. Ng, “ROS: an open-source Robot Operating System,” in *ICRA Workshop on Open Source Software*, 2009.

[8] M. Bischoff, “ROS#,” 2019, https://github.com/siemens/ros-sharp/releases/tag/v1.5.