



JARVIS

INTUITIVE ROBOT PROGRAMMING USING GENERATIVE AI



Funded by
the European Union

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement n° 101135708. The dissemination of results herein reflects only the author's view, and the European Commission is not responsible for any use that may be made of the information it contains.

GENERATING ROBOT PROGRAMS FROM NATURAL LANGUAGE

This module consists of the generation of robot programs from natural language. With the **GORP** module developed in JARVIS, the aim is to provide plant operators with the ability to produce robot programs that can be verified and fine-tuned before deployment. To achieve this, we propose the use of **Large Language Models (LLMs)**, which have proven to be valuable support tools for programmers. This module is a central part of the JARVIS effort to provide seamless **Human-Robot Interaction (HRI)** that is reliable in industrial environments.

FACILITATING OPERATOR-ROBOT COLLABORATION

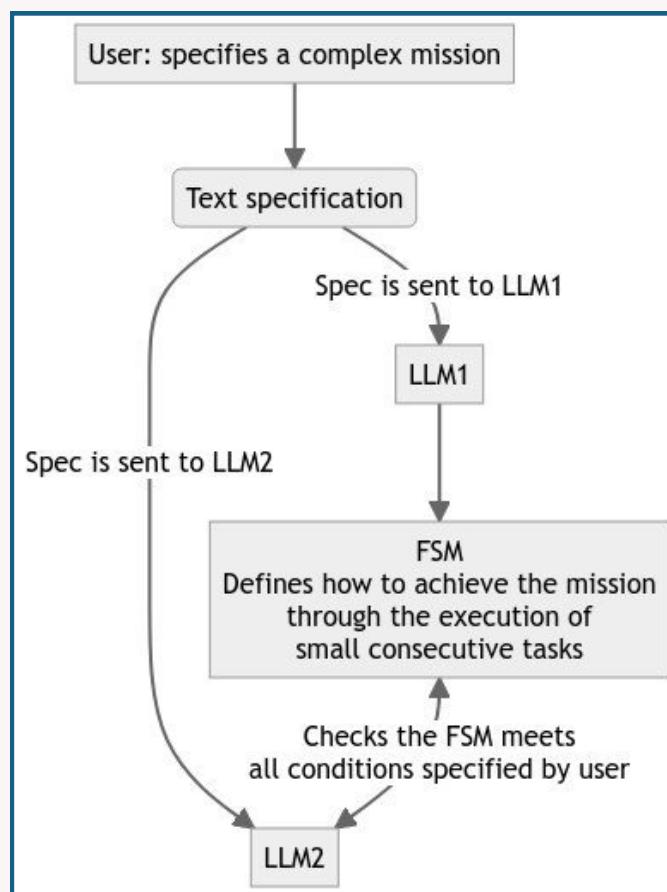
Integrating a robot into an industrial environment requires expert robot programmers to coordinate with operators who possess knowledge of the task to be automated. With the **GORP** module, the goal is to enable operators to directly describe the task to the robot, which will then perform it according to these instructions. The robot programs will be executed by the Skill Engine of the FLEXBOTICS system, a user-friendly programming system developed by Tecnalia. The Skill Engine allows programmers who are not experts in robotics or a specific robot to generate complex programs, such as those for the inspection of a plant. For this purpose, the Skill Engine abstracts specific robot functionalities into a YAML-based language.

For example, when we command the Skill Engine with a function such as "grab + object," it implicitly executes the necessary functions in the robot to grab the specific object, without the programmer needing to be an expert in that particular robot. Once one of these programs is generated, it can be reused at any time or even nested within more complex programs that are created manually. With recent advancements in generative artificial intelligence, it is now possible for LLMs to utilize these easy programming frameworks, such as the Skill Engine, to generate valid robot programs.



ENSURING RELIABILITY THROUGH VISUALISATION

For a robot application to be successfully integrated on the shop floor, it is essential to have certain guarantees. The **GORP** module allows the operator to visualize the content of the robot program before it is executed. This is accomplished through an intuitive **Graphical User Interface (GUI)** that showcases the individual skills and the order in which the robot will perform them. If the operator believes that the generated program requires any changes, the **GORP** module allows for further adjustments to individual skill parameters or the entire program's workflow via conversation or using the GUI. Thanks to the LLM ensemble developed within this module, the operator can iterate on the program or define new constraints, such as handling a new item that requires special attention.



ADAPTING TO DYNAMIC ASSEMBLY OPERATIONS

A potential application of the **GORP** module could be in a complicated assembly operation where the part to be assembled evolves over time. By utilizing the **GORP** module, operators can modify the robot program to adapt to changes in the assembly sequence, making the entire process more dynamic. This capability facilitates the integration of robots into flexible manufacturing environments, where historically, robots have been kept at bay.

THE FUTURE OF ROBOT DEPLOYMENT IN COMPLEX ENVIRONMENTS

At JARVIS, we believe that technologies like the **GORP** module can help bring robots into more complex environments through easier deployment and adaptability, leveraging the latest advancements in robotics and artificial intelligence.

