D3.2 SMARTHANDLE dexterity enablers – Final prototypes

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Revisions

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v0.1	18/05/2025	Table of Contents (ToC) release	UPC
v0.2	15/06/2025	1st round of contributions	All
v0.3	16/06/2025	1st full draft release	UPC
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V0.5	21/06/2025	Revision by TECNALIA	TECNALIA

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Acronyms and definitions

Acronym	Meaning
ODM	Overhead Dual-arm Manipulator
FFT	Fast Fourier Transform
CNN	Convolutional Neural Network
RGBD	Red, Green, Blue and Depth (for images)
FOS	Fiber Optic Sensor
FS	Fabry-Perot (for tactile sensors)
CAD	Computer Aided Design
FCL	Flexible Collision Library
ScLERP	Screw Linear Interpolation
UDQs	Unit dual quaternions
ALP	Automated Lens Production line

Abstract

This document presents the final technological advances of the SMARTHANDLE project regarding the dexterity enablers, which allow the smart interaction of dedicated grippers and tools with the workpieces to carry out the different manipulation actions as expected in manufacturing processes. In turn, this allows for a better adaptation to the varying conditions inherent to current industrial and processing lines (at both product and line levels). These initial advances are organized into four main areas aligned with the WP objectives: (1) the development and integration of grippers and sensorial systems specifically designed to enhance dexterous handling capabilities; (2) the implementation of versatile grasping and manipulation strategies capable of adapting to a wide range of object types and geometries, including both known and unknown items; (3) the implementation of algorithms that support the robust and efficient execution of manipulation movements under real-world industrial constraints by detecting objects and their properties, as well as humans and their postures; and (4) the consideration of human-robot collaboration by ensuring safe interaction in shared workspaces, including the ability to dynamically adapt behaviors in the presence of human operators. These efforts are directed toward practical applications across a variety of object types and working conditions, with special emphasis on sensorial enhancement, dexterous control, and human-aware interaction.

Executive summary

The main objective of the SMARTHANDLE project is to enable dexterous and intelligent robotic handling capable of adapting to the dynamic and diverse conditions of modern industrial and processing lines. This document presents the final technological outcomes related to the dexterity enablers, as defined in Work Package 3 (WP3), which directly contribute to this overarching goal. In particular, the purpose of this deliverable is to report on the developments carried out within the scope of WP3, which include: T3.1 – Sensorial system and mechatronics for proficient workpiece handling; T3.2 – Control methods for grasping of intractable and sensitive objects; T3.3 – Perception algorithms for operator and object recognition & localization; and T3.4 – Behavior libraries for advanced teaching methods of single/dual arm robots. Following the introductory section, the document presents the developed technologies across four key areas, emphasizing their integration into the three distinct use cases of the SMARTHANDLE project. A series of accompanying videos also demonstrate these technologies in action. The final section provides an overview of the progress achieved and outlines the next steps for refining and deploying these dexterity enablers.