



Smart-Assistant for Packaging using Deep Learning Agent

DIH² 2nd Open Call



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824964

Introduction

Consortium: SIA EKJU

Operating since 1992, reg. no. 40003051329, Latvia

The largest manufacturer of garden furniture in the region.

Exporting products to more than 25 countries including USA and other global markets

Turnaround 11m+ EUR per annum

224 employees

One of two factories
Located in Cesis, Latvia



Introduction

Consortium: SIA ASYA

Operating since 2018, reg. no. 40203171916, Latvia

Team of award winning Deep Learning scientists of top universities of the region.

Raised 0.5 mil investement from venture capital firms.

Successful products deployed for multiple manufacturing businesses.



Problem Description

Application Type: Manufacturing, Packaging

Main Process: Assembly

Generalised problem title: Vision based real-time quality control system to ensure the packages contain all required items.

Generalised Problem Description

At the end of the manufacturing process, there is a problem in packaging. Factories that make a large variety of products that are not preassembled and contain many pieces have a problem to ensure that low-skilled workers maintain attention to put all necessary pieces in the packages. For example, think of IKEA furniture that sometimes there are missing pieces in the kit. For manufacturers, that do not have their own distribution chains, this is a problem, because then the manufacturer will have to replace the whole kit with the furniture even if only single piece is missing. SIA EKJU who is one of the largest manufacturers of wooden furniture kits for the garden reports that up to 0.06% of their kits contains missing pieces that amounts up to 20k EUR losses per annum. Currently manufacturer is forced to do manual quality control of the kits that is prone to error and requires opening already packaged items. Garden furniture comes in a variety of shapes and sizes, many pieces are large heavy and volumes for each kit alone are not high enough to justify automatization of packaging process.

- * The content of this slide aims to provide the necessary inputs to evaluate the proposal according to the following Relevance Requirements in the Guide for Applicants: H-PR-01 and H-PR-02
- * Some tips in the Annex of this Short Template (Diagrams in Slides 24 and 25)

TTE Problem Description

Current Factory Scenario

Base Successful Production Cases	Challenging Production Cases
<p>The base successful production case involves cautious manual work.</p> <p>All components must be included, quality control must be done before sealing the package. There should be less than 0.01% of missing pieces in the package. Manual labor intensive packaging speed should improve more than 5% as managers can assign and incentivize the best suited employees to different packaging tasks using precise statistics of each employee production speed.</p>	<p>There are a number of challenges to base a successful production case:</p> <ul style="list-style-type: none"> • Items lie on top of each other and it is impossible to verify the contents of the packages after they are prepared for sealing • Product kits are in very different sizes and shapes, as shown on slide 10. Quality control process for each of the kits would require a lot of different procedures that would significantly slow down the production which is unacceptable. • Factory workers also have night shifts where it has been seen that their attention to detail decreases. • Not all factory workers are reliable and there might be some cases of theft.

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Proposed Solution

Smart Factory Platform Type(s): Quality control, smart-assistant

Smart Factory Platform Operation(s): Packaging

Mandatory Peripherals: USB camera, Raspberry PI, Touch Screen Display, Loudspeaker

Title: Vision based smart assistant that helps workers to maintain attention and check the contents of kits of products.

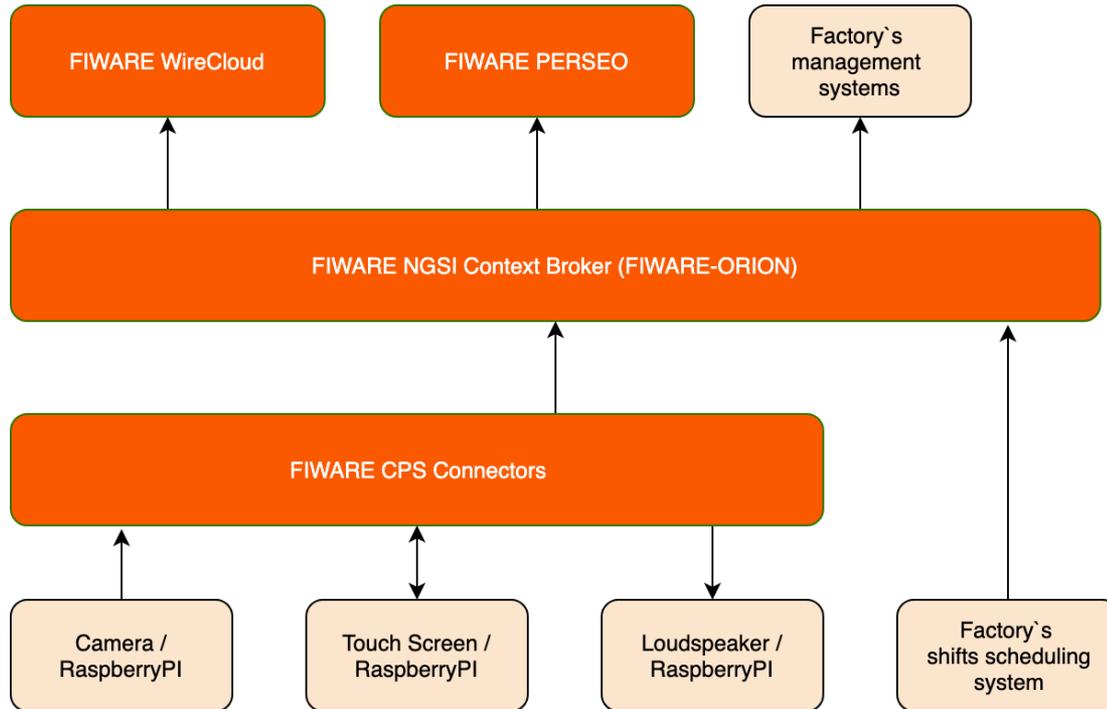
Solution Overview

Vision based smart assistant that helps workers to maintain attention and check the contents of kits of products. The system consists of a camera located above the assembly table on the factory floor. It automatically detects which kind of product workers packaged using a custom FIWARE CPr without the need for workers to specify the type of product. After detecting this type of product, the system checks if workers have added all necessary items to the package and done it in a correct order. If the system detects missing pieces, it sounds alarm as the factory is working 24/7 and workers might not notice other indicators. After getting alarm, the worker sees messages on the touch screen located by the table and corrects or dismisses the issue. The system registers all events in FIWARE ORION and afterwards it provides information about failed kits and false alarms in WireCloud using a widget. It also uses custom FIWARE CPr to give the context of shifts of workers working on the factory floor and better identify problems in the personnel. If workers on the factory floor keep ignoring alarms, then the system can send a notification to supervisors via FIWARE PERSEO.

- * The content of this slide aims to provide necessary inputs to evaluate the proposal according to the following Relevance Requirements in the Guide for Applicants: H-SR-01 and H-SR-02
- * Supporting slides can be found in the Annex of this Short Template (Slides 29 and 30)

Proposed Platform Design (1/2)

System of Systems View



Proposed Platform Design (2/2)

FIWARE-Ready Smart Factory Platform

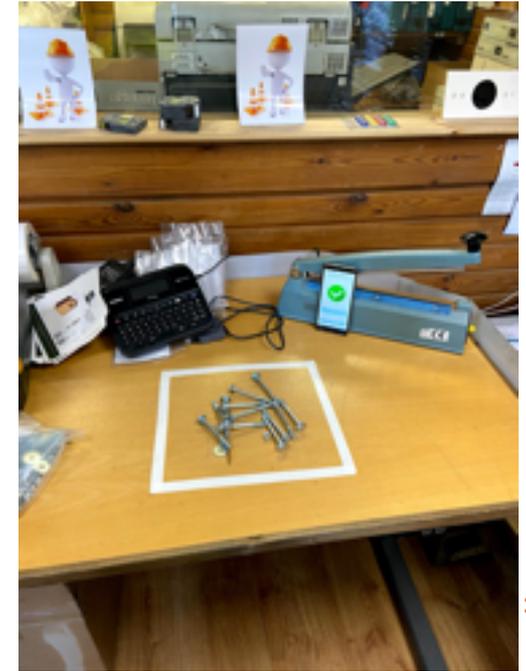
The system will use a number of FIWARE components starting from the basic FIWARE Orion context Broker and ending with custom widgets in FIWARE WireCloud and custom actions in FIWARE PERSEO. The system would be trained using instance segmentation models from correctly assembled kits. Correct model will be chosen automatically based on the type and size of the kit. The context of worker's shifts, location in the factory floor, and production schedules will be taken into account to make better predictions and recommendations.

Proof of concept smart assistant has been tested on the factory floor using a mobile phone platform, but the full system will be based on a more robust and integrated configuration using a touch screen, loud speaker, and properly positioned one or more cameras.

**Example of large kit of
Garden table**



**Example of small sub-
kit of bolts and small
pieces**



Technology Readiness Level

The system is currently in TRL 5 as both the technology that consists of deep learning models and application to packaging have been tested in multiple visits to the factory floor. The goal is to reach TRL 7 and implement multiple sets of smart assistants on at least 4 locations in the factory. Deep learning model required for the task previously has been published in scientific journals by the technology provider and has successfully been applied for segmentation of damaged wooden planks in another project.

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Excellence Requirements

(Soft) Quality Requirements



Target Scenario

Envisioned Factory Deployment

Targeted Base Successful Production Case for the envisioned Factory Deployment

The system ensures quality packaging with less than 0.01% uncomplete kits of furniture. In case the distributor claims missing pieces in the packaging, then the system provides logs of data that confirms the checks performed and the manufacturer can look for problems downstream in the distribution chain. The system also allows to measure the packaging speed and efficiency of each employee and allows the manager to select the correct type of personnel for each of the packaging tables. In this way, the production efficiency would improve up to 5%, because the packaging step is one of the most labor intensive steps in the manufacturing process.

Main Risks Identified (High / Medium /Low Impact)

The main risks of successful deployment:

- Lighting conditions are not sufficient for the system to work properly (low impact), which can be mitigated by adding more lighting
- Precision of the models is not sufficient, producing too many false positive alarms (medium impact), which can be mitigated by labelling more training samples of correctly assembled kits of furniture
- Mix-up of different types of product kits when the parts and their layout are too similar (medium impact), it can be mitigated by manual intervention to change the product type
- Factory workers might override or ignore the system (medium impact) then senior management could enforce discipline.

Target Scenario

Goals, KPIs and Experimental Methodology

Goal <Id, Name>	Achievements (KPIs)	Assessment	Risks
1. Reduction of missing pieces in large item packaging process	Less than 0.01% of packages have missing pieces.	Statistics of reports from product distributors.	Packages gets breached in warehouses after leaving factory floor.
2. Reduction of missing pieces in small item packaging process	Less than 0.01% of packages have missing pieces.	Statistics of reports from product distributors.	Packages gets breached in warehouses after leaving factory floor.
3. Optimization of packaging speed	At least 5% of increase in packaging speed.	Statistics from the manufacturers system with regards to baseline packaging speed.	High speed manual packaging process might not be sustainable resulting in high employee churn.

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Preliminary Ideas on the Exploitation Plan

Manufacturing Company

The system can be extended to monitor also other phases of manufacturing processes. For example, currently there is a problem of properly registering incoming supplies in the factory. Most of the supplies have QR tags or printed packaging notes on them, but they are in different format depending on supplier. It takes 1-2 full-time workers just to write down all variations of labels and enter the system of the factory. Vision based assistant solution would greatly reduce amount of work to the workers and improve precision of data entry. The Deep Learning model could be also applied to track and study the movement of items within the factory. It would produce maps of the most common routes in the factory by placing cameras covering the factory floor. This way, factory managers could change operational manuals to improve the efficiency of the manufacturing process.

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Preliminary Ideas on the Exploitation Plan

Technology Providers

The Deep Learning models can be made of different types of architectures and using different types of data. Higher accuracy of detection could be achieved by using higher frame rate and higher resolution cameras. Other types of sensors also might be added to the models using sensor fusion. For example, on some packaging and manufacturing tables, depth cameras might be useful. If factory personnel have their consent, it could be possible also to track the identities of workers at different locations on the factory floor from their faces. This would improve the security and efficiency of production as managers could track meta-data of the production output of each employee.

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Use Case



Use Case Template (1/5)

Challenging Production Case

Title: Packaging of garden table kit using manual quality control

Short Description:

Currently, manual quality control can track only 0.01% of product kits on the factory floor. The same packaging tables are being used to package a large variety of product kits. Shifts work around the clock 24/7 and the efficiency is only measured by the production output for each of the shifts. Often for large items like garden tables, it requires more than one worker to package a kit.

Required Smart Factory Capabilities

Real-time Supervision

Efficient Historical Data Management / Analysis

Computer-based Optimisation at Asset, Process, Plant, and/or Business Levels

Main Actors, Systems, and Factory Assets Involved

- packaging employee, packaging manager, packaging process monitoring system using FIWARE, HCI

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Use Case Template (2/5)

Proposed Solution

Solution Title and Short Description

Title: Packaging of garden table kit using smart-assistant

A packaging employee works on packing a large garden table with a partner. They accidentally misplaced one of the required parts. The smart-assistant-based system gives an alarm and workers resolve the issue. Afterwards, they are more careful and complete all other packages without warning. Later, a packaging manager reviews the process using FIWARE WireCloud and identifies that a partner works only 50% of the time and decides to change an employee in a particular shift, thus improving the efficiency of packaging.

Implementation of the new system reduces missing pieces in the kits to 0.01% of packages and increases packaging speed at least by 5%.

Use Case Template (3/5)

Summary

Targeted Capability	Smart-assitant Responsibilities	Digital Platform Responsibilities		Custom/Legacy System Responsibilities
		Standardised (Powered by FIWARE)	Custom	
Quality control of packaging	Warnings to packaging workers when pieces are missing	Using context of product types and shifts of workers provide statistics and even-based notification to the management	-	-
Optimization of packaging process	Monitoring efficiency of groups of workers and shifts	Using context of product types and shifts of workers provide statistics and even-based notification to the management	-	Existing manual shift scheduling system.

Use Case Template (4/5)

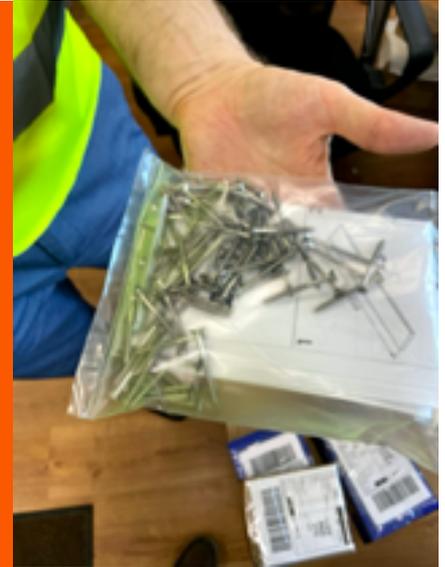
Slide

Information Sheet – Smart Assistant for packaging

Main Features:

- Is the system already in the factory? – No
- If not, Is it clear which system will be used? - Yes
- Main Technical Specifications – Camera-based system using deep learning models and easy to use HCI
- Main Responsibilities for the smart factory platform – Ensure quality control and improve packaging speed
- Main responsibilities for the physical environment - Collect data for models
- Resources to be consumed – Electricity, human resources

- **FIWARE-Ready - Yes**
- **Other Interfaces – Integration with existing factory`s IS**



FIWARE NGSI

The system provides and consumes NGSI context data. Main attributes for NGSI entity – product type, employee id, packaging time, warning count.

Additional Comments:

Existing factory`s IS include context information about shifts of employees, types of products, etc.

Use Case Template (5/5)

Slide

Information Sheet – Employee of packaging

Role Description (Highlights):

What? Employee puts together the package of small items in a kit that is necessary to assemble the final product. Employees might need to assemble a variety of kits during the day that have different, but similar configurations of items.

Why? Using the system, the employee can get extra incentives as managers can track their efficiency and attention to detail using the statistics provided by FIWARE WireCloud widget.

How? Using the system, the employee gets a warning if the kit is containing missing items and the employee can correct himself/herself.

Additional Comments: -

Use Case Template (5/5)

Slide

Information Sheet – Manager of packaging

Role Description (Highlights):

What? Manager of packaging is responsible to ensure a agile manufacturing process and an efficient quality control process before shipping out products.

Why? Using the system, manager can get extra incentives as the overall production speed would increase.

How? Using the system, the manager can get preemptive warnings using FIWARE PERSEO and statistics in FIWARE WireCloud to plan better execution strategies.

Additional Comments: -



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