ARTiCo - AR in Tissue Converting

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***Abstract*—For fully up-taking the advances achieved in pervasive monitoring systems within Industry 4.0, novel intelligent interfaces are needed to ease interactions with human personnel and enable them to access the available data and services ergonomically. To this end, we present a mobile app based on augmented reality that allows operators to receive location-aware notifications and access and visualize real-time information and guidance for troubleshooting and plant maintenance. The app has been tailored to respond to the needs of a specific scenario, i.e. tissue converting, where it has provided encouraging results.**

***Index Terms*—Augmented reality, mobile app, predictive maintenance, pervasive vision, smart cameras, tissue converting, industry 4.0**

I. Introduction

Industry 4.0 is demanding new solutions to manage the multiple resources available in a production plant and integrate and orchestrate all the processes that should be performed. Besides the general production –which is often assumed to be the default mode– maintenance is of key importance since, in principle, it has to be performed so as not to interfere with production, keeping productivity at optimal levels and guaranteeing the expected quantities of delivered product [1].

In this context, technological solutions which can improve these aspects are always sought. Considering the rapid advancements in Information Technologies, particularly those concerning Augmented Reality (AR), what we present in this paper is a prototype demonstrator developed to support the maintenance of industrial tissue production lines. The paper is structured as follows: in section II, the reference scenario for the factory under investigation is presented; the subsequent section III describes the technical implementation and novelties of the app; while the final section IV shows the results and outcomes of the application of the demonstrator into a working factory environment.

This work has been partially funded by Regione Toscana POR-CreO Project IRIDE.

II. The tissue converting scenario

Tissue converting lines represent one of the vital plants in the paper production field. In such plants, paper tissue is converted from jumbo rolls, weighting tons into their final form for domestic and sanitary use (e.g. towels, napkins, toilet paper). The process is achieved through a line of machines that cover unwinding the jumbo rolls, pairing multiple plies of tissue, embossing and printing them and finally rewinding the product on logs of the desired radius to be cut into rolls of the requested length.

A highly efficient, strongly coordinated and robust process is key to making converting profitable. Therefore, the machines in the line must be orchestrated to work at a fixed speed, reaching 800 meters per minute while minimizing possible downtime. This goal is achieved through a mixture of advanced automation and Industrial Internet of Things (IoT) in modern converting lines. Several sensors are used for fine control and auto-regulation of each machine through a pervasive system. For instance, cameras might be used to control the quality of the tissue plies and identify defects that might lead to a paper jam. This way, faults can be predicted, and adaptive maintenance can be performed. Further, the information collected by each machine is gathered and shared with other devices. In such a way, a global orchestration of the processes on the converting lines is achieved. Notably, resulting in the definition of working speed (in terms of meters per second of tissue) and the optimization of cleaning and maintenance.

To be fully exploited such pervasive information requires the development of novel intelligent interfaces for the operators to enable them to monitor the line in real-time and be timely informed about events requiring their intervention [2], [3].

For these reasons, tissue converting is a scenario where the integration of solutions for Industrial IoT, pervasive computing and intelligent user interfaces may have a great impact and pave the way to applications in other domains linked to the Factory of the Future.

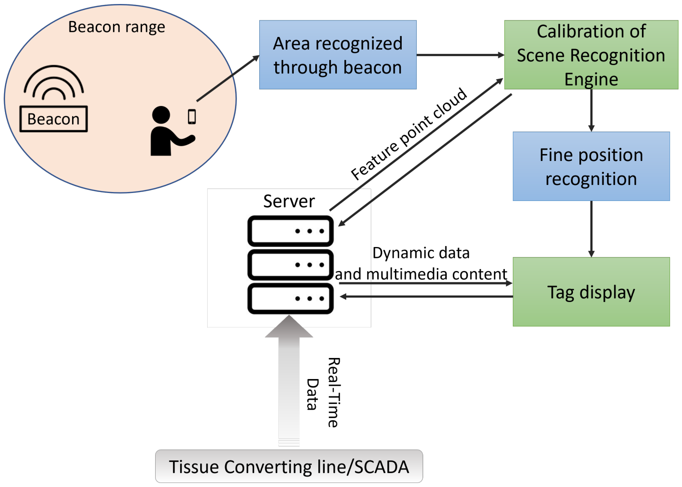

Fig. 1. Diagram of ARTiCo operational flow, position identification steps are depicted in blue

Fig. 2. An AR interactive tag relative to a complex component of the tissue converting line.

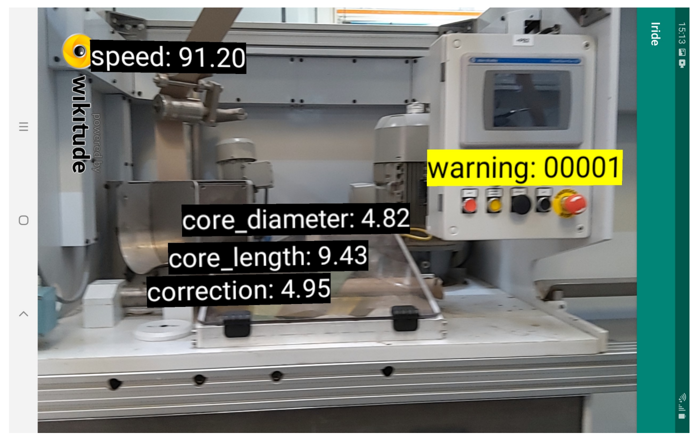

Fig. 3. ARTiCo interface in landscape mode after fine position is recognized. Displayed targets contain dynamic data gathered from the server

III. The Demo App

The prototype ARTiCo has been designed and developed to act as an AR useful tool during the tissue converting line inspections and during ordinary and extraordinary technical maintenance operations. ARTiCo exploits Wikitude framework [4] to recognize one or more target objects of the observed scene in order to understand the position of the operator. Thanks to this framework, the prototype is able to place inside the scene a set of AR content that operators use to assess the working conditions of the line and, in case of assistance is required, the prototype can display a set of documentation and step by step procedures that support the operator during intervention operation. Despite the Wikitude framework being a powerful and easy to use tool to recognize the scene and surrounding environment, it has some limitations that prevent its use in recognizing the entire tissue line due to the line size. Therefore, a set of Bluetooth beacons are placed all along the line to perform a coarse recognition of the examined portion of the line and retrieve the right feature-points cloud used to perform the precise position recognition via Wikitude.

The feature-points clouds are obtained by exploiting Wikitude Studio; Wikitude studio is able to generate a three-dimensional point cloud from a set of images of the scene. Thus, the prototype has to pass through two phases of training. During the first phase, each portion of the tissue converting line is photographed, and the relatives feature-points clouds are obtained. The second phase is devoted to associating each point cloud to the proper beacon displaced along the tissue line.

Fig. 1 shows a simple diagram of a typical ARTiCo use case. Once the operator is within the range of a beacon, the app recognizes the explored portion of the line and queries the server in order to retrieve the feature-points cloud relative to the visited area. With this point cloud, the recognition engine is able to locate the scene target object used to understand the displayed portion and correctly displace visible AR content. In the meanwhile, another component of the prototype is in charge to retrieve, from the server, real-time data and multimedia content to be displayed. Indeed, the app can provide three different types of tag: (i) real-time data, (ii) multimedia content (e.g. video guides, component documentation, 3d schema), (iii) interactive tags (e.g. step by step guides for assistance intervention). Real-time data, that is gathered by the server from the Supervisory Control And Data Acquisition (SCADA) for the converting line, are displayed as AR tags in the scene, which are automatically updated at predetermined intervals of time; multimedia contents vary from documents that can be opened through an external link to images and video that are displayed and can be played directly on the scene; interactive tags are a set of tags that operators can use in order to perform dedicated actions, such as proceeding to the next step of an intervention guide, retrieving detailed information about a complex component (such as shown in Fig. 2) or analyzing the abnormal status of a component of the line.

Fig 3 shows an example of the interface, in detail, a set of real-time values gathered from the server are displayed; the warning tag reports an error code and indicates an abnormal status in the operation of the line.

IV. Results

ARTiCo has been tested and demonstrated using two devices: a Xiaomi Mi 5S Plus smart-phone and a Samsung Galaxy Tab S5e tablet. The camera characteristics of the two devices are reported in Table 1. At the same time the portability over a smart-glass model (i.e. the Epson Moverio BT-350) is under development.

TABLE I
Camera characteristics of the two devices.

Device	**Xiaomi Mi5s Plus**	**Samsung Galaxy Tab 5Se**
Resolution (MP)	13	13
Aperture	f/2.2	f/2.0
Focal Length (mm)	34.88	26
Sensor format	1/4.3”	1/3.4”

The results, as also mentioned in [5], are promising both on recognition of single targets and on complete scenes in simulated environments (Fig. 4) and in the real factory (Fig. 5). The analysis performed were based both on the number of images used for the point clouds generation and the efficiency, in terms of recognized target occurring within a predefined slot of time over the total amount of targets.

Fig. 4. An example of the use of ARTiCo app in a simulated lab environment, with the item under examination highlighted in AR.

The demonstrator results show a very promising trend in terms of usability and robustness. A refinement in the acquisition and reconstruction steps is under development as well as an extension of the AR content.

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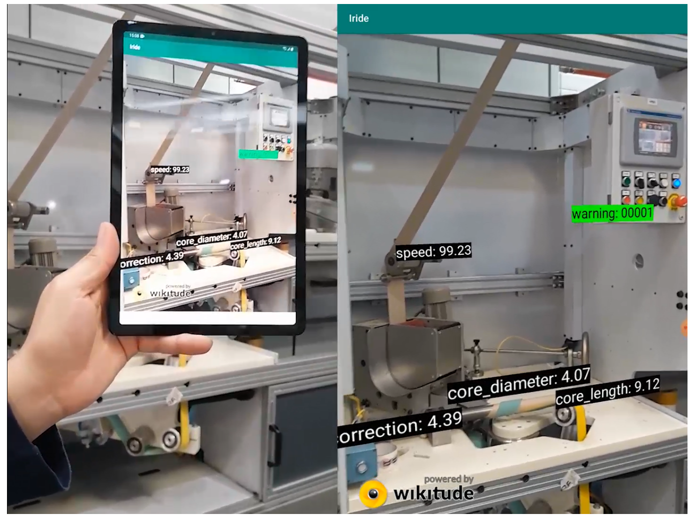

Fig. 5. An example of the use of ARTiCo app in the real factory environment: left side, operator point-of-view; right side, screenshot of the app.

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