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BIM and Mixed Reality for the new management of storage area

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Abstract The fourth industrial revolution that has touched the last decades, has involved several sectors including the construction world. The digitization and automation of industrial processes has implemented the development of connection platforms that can communicate many information for different users such as Smart Glasses or immersive headset. Most of the time, innovation does not only concern the technological field, but involves the entire organizational and managerial sphere. Digitization allows new tools such as Building Information Modelling to expand its application scale, making it an excellent tool for integrating and sharing data with their own information management systems (MES). The aims of this contribution are reproducing a virtual warehouse through parametric digital modelling, to which all the management data have been associated; for example, the average stock, the rotation index, etc. Thanks to the export of the database extrapolated from its management system of the analyzed industry, it was possible to define the correct visualization of the virtual model, interrogating the real data coming from the real warehouse. Through Smart Glasses, the user of the area could allocate the products in the correct position and update in the cloud the information properties associated with the individual product and the entire department. The use of virtual platforms for the visualization and the sharing of the data, facilitate the optimization of the industrial processes.

Keywords: Mixed Reality, Industrial Processes, Building Information Modelling, Digital Twin, Industry 4.0

1 Introduction

The technology revolution, that has involved the last years, have generate the new system for the managements and maintenance in the innovative industrial process. The new vision of modern industry involves technological progress in various fields. For example, optimized systems for production management and planning

make use of automated processes to obtain data from production lines and machines. (Roblek et al. 2016)

The industry sector has invested significant resources to integrate intelligent systems and interconnections into its information system for management (MES). One system that guarantee the control of the process thank an interconnection between differ lower system is MES. This method is used for the planning of activity in the production, maintenance the orders, the response to random events and the adjustments of plans and the following-up of activities. (Blanc et al. 2008)

During the time, the information system that different industries adopted has suffered computer implementations for reduce and simplifying the data loss. (Mantravadi et al. 2018).

Therefore, the installation of intelligent devices and local sensors helps maintenance and allows the factory to be digitized by turning components into intelligent resources. The element that characterizes the new production system is the integration between automation systems such as the Cyber Physical System (CPS) and the interoperability of the knowledge and skills systems within Industry 4.0 (Buchi et al. 2019).

The Cyber Physical Systems are defined as an enabling technology. By combining acquisition systems with enabling technologies, interoperability between systems is guaranteed to implement current industrial methodologies (Lee et al. 2015).

For evaluation of the new system it is necessary to define alternative methods to the classic way to represent the factory, using the virtual modelling, advanced artificial intelligence (cognitive) for process control, which includes autonomous adjustment to the operation systems (Rodic, 2017). Thanks to these innovations, was introduce the concept of Digital Twin, extending the use of modelling to all phases of the product life cycle. The Digital Twin is defined as the virtual model similar to the real object, used for simulated and generated specific process and method. Once tested in the virtual setting, the information was transfered within the factory by comparing simulated data with real data (Negri et al. 2017). Given the great potential that virtual models of simulations outline within a process of optimization and innovation was possible to use the Building Information Modelling as Digital Twin becoming a large repository of alphanumeric and three-dimensional information.

In this contribution, the Digital Twin is used as a 3D virtual model, for simulated and processing the information came from external database. For this reason, the Digital Twin could become an emulator for evaluated different efficiency scenarios in term of time and cost in the industrial areas.

In this context an example is the Regional project DISLO-MAN (Dynamic Integrated ShopfLoor Operation MANagement for Industry 4.0), which aims the creation of an Information and Communication Technology (ICT) platform for the integrated, dynamic and autonomous management of production operations to

optimize the use of resources for the creation of new connections between people, materials and production systems. In order to achieve the goal of the project, a virtual warehouse has been reproduced through parametric digital modelling, to which all the management data have been associated; for example, the average stock, the rotation index. This method has defined the correct workflow to connect different platforms and sharing data. After connecting the Building Information Model with the management system, data could be extrapolated to analyze and update them in real time through Mixed Reality applications. In this way employees could manage the operation without loss of data of products in stock in their department. Through headset, approaching the product with its own identification code, a series of useful operations appear to update the database, each time it changes stock and position within the building. By adding a virtual mini map, it was possible to identify and track the product within factory, studying the smartest time and route to apply to reduce inefficiencies related to the production chain.
The challenges brought about by the industrial revolution involve digitalization through new control systems that use Virtual, Augmented and Mixed Reality systems to facilitate the individual worker, reducing errors and management costs. In this direction, dataset and database become the focus of innovation, studying methodologies and systems that could preserve it, but at the same time make it accessible to all without compromising its integrity.

2 Case study

The DISLO-MAN platform was born from the need to make local companies competitive with highly specialized personnel supported by Internet-of-Things (IoT) technologies in their various nuances. In particular, the project involves the use of wearable sensors, systems for the indoor location of operators and automated material handlers such as AVG.
To facilitate the acquisition of data from sensors located on machines, conveyors, goods in storage and operators, it was possible to create a shared platform in which the data flow in a raw way and then processes them with data cleaning systems (Apiletti et al. 2018).
Once reworked, machine learning software systems could analyse complex production scenarios and provide viable alternatives, optimizing human and economic resources. In addition, the platform provides for the integration of production systems with machine productivity parameter data, thanks to the sensors installed, to optimize the flow of materials and minimize downtime. With IoT systems, the user of

the future users will have the opportunity to be guide by motion recognition systems to make their job even more ergonomic.
Through statistical and comparison methods, real-time processed data ware trained to create predictive models, in which digitization highlights best practices to be visualized through Augmented Reality and Virtual. In this way Smart Glasses, Cave, Immersive Training Systems, become excellent tools to evaluate the performance of human activities.
The benefit that the project adds to the local industrial system characterizes three fundamental aspects. The modularity applied to shop floor contexts of different nature, to create a dense network between sensors and data standardization rules with simplified access interfaces. Interoperability then plays a central role, thanks to integration with existing information systems. In this way, using the resources available on the market, interoperability compares the results of different sectors in a platform that unifies the data collected in a common language. Finally, the platform tries to use the same types of software to manage different hardware and visualization systems in different shoopfloors. In addition to these innovative aspects, through middleware, data analysis algorithms and machine learning, independent systems with dynamic integration created to manage and control the industrial process throughout the entire production cycle.
The opportunity introduced by the Dislo-Man project was strengthened by the local production system by involving many industrial partners, companies supporting the IoT and research institutions. In terms of numbers, seven large companies located in Piedmont and Valle D'Aosta, twenty-eight partners for the IoT, two research institutions (Polytechnic of Turin and University of Turin) and as many as one hundred and twenty people involved throughout the project. Started in October 2016 and ended in October 2019. At the end of the project, the impact of economic/management skills was assessing, increasing new business models and turnover for the SMEs involved. Within the innovative systems it is feasible to introduce the methodology of Building Information Modelling (BIM) to return in three-dimensional form the building and the sub-components, in order to determine also a database in which all the alphanumeric information associated with each element converge; e.g. relationships between different objects, materials, costs, construction phases, etc (Osello, 2012).
The use methodology in order to achieve the project's objective, optimized the entire production chain thanks to the creation of the BIM model that connects and facilitates access to the data processed within the Dislo-Man platform. Being able to create a unique parametric digital model, it could be shared among different users and keep its alphanumeric properties unchanged during the different simulation phases. The model hires the role of Digital Twin, useful to diversify different scenarios and implement data from internal information systems.

3 Methodology

Workflow

Through the identification of input needed in Fig. 3.1 to define the correct workflow, it is possible to connect different platform with many domains and data share. In the first phase of creation's Digital Twin model as Building Information Modelling is important to identify the parameters and metrics required to optimize the management of technical areas. For this reason, the model is based on the internal database came from by the industrial system information.
The data of virtual model could be transferred into free platform on web, using query system. In this way, more users and more instrument have to the possibility to access at the information obtained sharing the model.
What characterizes this process is the uniqueness of data, editable using Mixed Reality applications. Moreover, the actors of this method could compare many information with the real situation, so the process is validated. During the final phases the model with his information could be updated in real Time in the web platform and imported them into geometric model. Is important to connect the new model with the MES for generated a unique virtual system.



Fig. 3.1 Workflow and methodology use for innovating the industrial case study

Digital model as Building Information Modelling

The BIM model by its very nature, in addition to the geometric aspects, preserves, through associations of parameters, data from various sources such as technical data sheets, tabular values relating to the production and allocation of products, safety data sheets allowing an integrated approach with respect to the information that each element may contain.
In this way, by combining several paper archives in digital format, there will not be duplication of information but an immediate geometric and alphanumeric correspondence of the selected object. To obtain a good graphical database, it was useful to stable the appropriate level of detail (LOD) to ensure an adequate level of information and representation without losing definition and evaluate the appropriate visualization through virtual interfaces diversified according to the final goal. The acronym LOD varies according to the regulatory context in which the BIM model was developed. Among the definitions it is useful to mention the American Institute of Architects description given in the 2013 year. This level of development considers the quantities graphic of the information insert into BIM model, so in every object the information is select based on phases choose (Abualdenien et al. 2019).
This definition clearly explains the need to establish minimum dimensions, spatial, quantitative and qualitative in an element of the model based on the uses (De Luca, 2019).
In addition, a ranking was established with five levels from 100 to 500, which are associated with geometric and alphanumeric requirements. With an LOD 100, the model was conceived by means of generic masses without any level of detail, in the LOD 200 it is possible to define an approximate geometry of the elements, instead from the LOD 300-500 the level of modelling begins to be elevated until the obtaining of a Digital Twin identical to reality. Following the classification, the BIM model created follows three types of LOD. For the building envelope, the modelling complies with an LOD 400, while for the machinery, an LOD 300 was chosen, integrating the missing components through the insertion of related alphanumeric parameters.
Finally, for the warehouse and its products, the modelling follows a LOD 100 defining the volumes and spatial dimensions, leaving room for alphanumeric indexes. The peculiarity of this methodology is the great opportunity to create hierarchies of data easily manageable and interoperable with non-BIM platforms, through overlapping schedules. Through specific plugin, the BIM model was populated with useful information present in the MES system, selecting what to display in the geometric model. Once again, the interoperability, even if with small gaps, could be satisfied and the integration between different systems is guaranteed by web dashboards able to visualize the data. The more closely the model was aligned to the

objectives, the more the reliability of the process meets the physical and functional requirements that the fourth technological revolution requires.
For these reasons, an example of a process of storing goods between different demonstrators was identified for to be replicate within a new container, through the main functional characteristics. This choice allows the system to be flexible and to generate data on a geometric level for further scenarios. The structure used to test the BIM methodology in the industrial field is the former complex of turning shop located near the Polytechnic of Turin. In Fig. 3.2 the virtual model created contains only the outer casing and the horizontals and vertical connections. The entire supporting structure of the roof has been preserved in order to evaluate, in subsequent studies, the logistical dimensions of the entire production line.

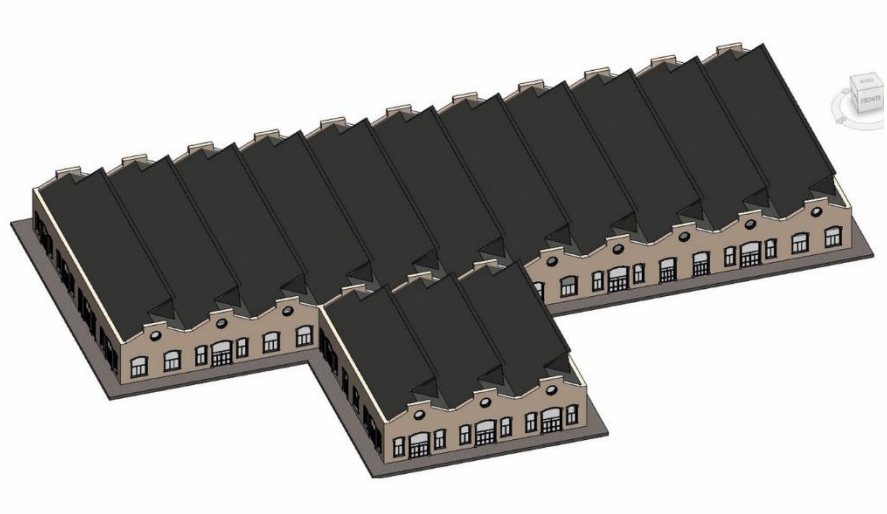


Fig. 3.2 BIM model of case study

The choice to relocate the spaces comes from careful studies on the different production layouts, preferring a large space able to resemble in shape and size to the real model of the warehouse, the focus of this contribution. Based on the information received, the choice of placing the storage department in the central building was in accordance with the actual size and number of racks. By calculating the maneuvering areas of the forklifts, the maximum size of the racking and the number of openings required for the goods, the virtual warehouse could be considered to all intents and purposes to be similar at the real.
After allocating the different departments, the study focused on digital modelling of the warehouse. The maximum number of racks and pallets that represent the useful

dimensions of the products, derives from the standard dimensions of the norm UNI-EN 13698-1. There are various criteria for the classification of the warehouse loading units of the categories of units stored, the level of automation (manual, semi-automatic, automatic) and finally the status of the material.
By identifying the load units and following the instructions in the standard, the distance between the racks considers the means of handling such as forklifts or AVG that could help the operator in picking up and arranging the products. In this case, the minimum clearance guarantees a minimum maneuvering space of 1.20 meters for three-way trolleys. Combining the different requirements, a storage model has been obtained: with variable containers allocated unevenly according to size, automatic automation systems for picking and direct control over the most fragile products. Each volume has been associated with an identification code, a specific coloring to display the position occupied and all the parameters useful for the correct management of the products, deriving from files linked to the MES. The products of the department, following the priorities of variable handling based on the index of rotation and type, need a clear coding that identifies all the parameters useful in the different phases of allocation. (Rimella, 2018)
The mapping of the products was carried out by identifying three classes of access to the articles, the layout of the shelving and the crossing policy provided, and the articles are positioned with the aim of reducing the main picking times: distance of the route, search for material and withdrawal of the codes indicated in the order. (Graziadei, 2004)
In fact, through the re-elaboration of the data, a matrix has been created. It contains the values of the average stock, the annual consumption of the product obtainable from the accounting sheets and the cost on the market of that specific element. (Rimella, 2017) In this way, it was possible to obtain the rotation index that allows to correctly allocate the products. To facilitate the modelling, in Fig. 3.3 the virtual model is trained for the visualization, using specify script to calculate the tabular values.

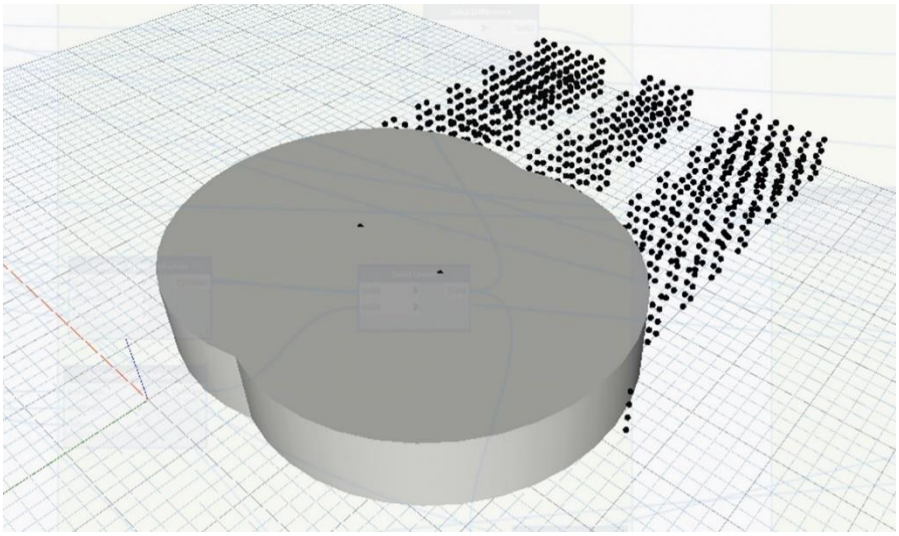


Fig. 3.3 Dynamo script to identify storage areas

Each object of the model has been associated with the alphanumeric identification code, the rotation index, the storage area and the condition (occupied/free). The Condition parameter, a material has been associated which, according to the zone, retrieves its status during the day. After having established the rotation index below which a product must be allocated in zone C and the index above which a product falls in zone A, it was necessary to size the different areas of stock so as to be able to draw every single movement of the product. The visual programming software Dynamo was used to do this. Through the programming, the comparison between the indexes inserted in the BIM model and the rotation index of the categories of articles reported on the external file, the model highlights the number of elements that should be contained in the single zones. After this is necessary to calculate the minimum radius that should have a circumference with the center of curvature in the middle of the exits in the warehouse. The need to calculate this value arises to define the width of zones A, B and C. These relationships extract the positions of the elements placed on the shelves of the digital warehouse; these allocations are read and represented in Dynamo as points of coordinates x, y and z. It was therefore useful to intersect the volumes of the cylinders previously created with the positions of the elements in order to identify exactly the objects in the zones. The comparison of lists was done to overlap heterogeneous data and special character using Python scripts.

Once the areas with elements of the model that are part of it have been sized, all that remains is to modify the parameters of the selected objects by entering the

information provided in the external file. By varying the material with a new one previously created, it is possible to view the maximum and minimum capacity of the warehouse, whenever the external files could be modified. Thanks to the use of linked database, with special scripts the model receive the changes and they will adapt at the new indications. During this operation, sometimes an overcrowding or an undersized department emerges. In this way is highlighting the lack of some areas with insufficient space to accommodate all items. In the Fig. 3.4, the digital model, by means of an "alert", warns the operator of the problem encountered. Once again, through visual programming, it is possible to return a message indicating which area has been undersized and how many products remain outside the shelving. Following this methodology, the simulation model, returns different values and characteristics both at the level of the individual product and of a general management of the department.



Fig. 3.4 Overcrowding of products in the selected area

BIM parameters and management indices

The logistic system was defined as the set of organizational, management and strategic activities that govern the flow of materials from the purchase of raw materials from suppliers to the delivery of finished products to customers and the after-sales service.

Indices and parameters were defined that were able to improve the efficiency of the raw materials storage system, the correct allocation and elimination of the final product. (Vignati, 2002)

These indexes described in the previous paragraph have been inserted into the BIM model through scripts for each individual product. In Table 3.1 are shown the example of products with the specific index using for evaluating the efficiency of stockage. After this first operation the second step is to create for each object of digital model the camps featured in the external file. Using script, every information is reading and associate at the object that have those camps. This passage is automatically because the script recognizes the ID number for each object and read the camps associated.

To evaluate the correct use of data, the rotation index was used, highlighting which articles remain in the company and for how long. This is also classifiable according to the type of factory and products made; many companies that produce fresh products will have a high index while other types of industries are characterize by low values. In order to avoid goods occupying unnecessary space and risk being ruined by time, the turnover rate is the optimal solution to reduce losses. This index could be calculated by the ratio between the outputs of a period and the average stock in that period. (Urgeletti Tinarelli, 1981)

The reference period can have a variable size, referring to the single product, to groups of articles or to the entire warehouse. In the case study, the rotation index considers the single product present in the area during the whole year. Another parameter evaluated was the average stock the quality/value of the articles in the warehouse. These indices are added thanks to the management software, by entering the purchase data and the products deriving from the production line. Analyzing only these two factors, the virtual model developed could be considered a dynamic compact warehouse. The advantage was the reduction of infrastructure management costs, standard handling equipment and a high level of space saturation.

Items	Class	Average stock	Annual consumption	Price (€)	Stock value	Consumption value	Rotation index
Enapren 20mg	Class A	141	1.831	11,31	1.594,71	20.708,61	12,99
Aulin bs	Class A	219	1.713	4,91	1.075,29	8.410,83	7,82
Ciproxin 500	Class A	68	298	14,4	979,20	4.291,20	4,38
Dostinex 0,5 8cpr	Class A	2	15	57,11	114,22	856,65	7,50
Totalip 20mg	Class A	3	105	54,9	164,70	5.764,50	35,00
Tavor 1,0	Class C	106	990	6,3	667,80	6.237,00	9,34
Muscoril f.le	Class C	7	287	10,35	72,45	2.970,45	41,00
Gentalyn Beta cr	Class C	7	317	13,97	97,79	4.428,49	45,29
Xanax 0,5	Class C	14	265	6,83	95,62	1.809,95	18,93
Glucobay	Class C	2	74	13,94	27,88	1.031,56	37,00
Neolactoflorene fl	OTC	292	342	8,7	2.540,40	2.975,40	1,17
Aspirina C 20cp	OTC	204	881	6,9	1.407,60	6.078,90	4,32
Tachipirina 250	OTC	74	414	4,1	303,40	1.697,40	5,59
Moment 200 24cp	OTC	77	395	7,8	600,60	3.081,00	5,13
Maalox Plus sosp	OTC	60	76	5	300,00	380,00	1,27
Garze 10x10x100	Other Products	80	183	2,3	184,00	420,90	2,29
Euphralia coll.	Other Products	27	151	6,8	183,60	1.026,80	5,59
Mediker sh antiparass.	Other Products	45	129	8,9	400,50	1.148,10	2,87
Saugella derm.liq 500ml	Other Products	29	53	9,3	269,70	492,90	1,83
Chicco Gommotto	Other Products	6	51	3	18,00	153,00	8,50

Table 3.1 Management indices

Since some items could remain in their storage area for a long time, the coverage index obtained from the rotation index, allows to assess the time of inefficiency of the system and understand the maximum demand for the article in the global market. Once the indexes were established and the areas of reference identified, each article was coded according to precise rules. (Antonelli et al. 2012)

Each code contains classes, subclasses, subgroups, types, subtypes, articles, starting from the general category to the single detail. In our case, each component has a part in letters indicating the area of stock, the subclass in numbers and then the progressive that follows the position of the article. In this way, in addition to simple sequential coding, allows a range of values to be assigned at the sub-areas, facilitating the identification. If the coding is clear and unambiguous then there will be a good precision between the code and the article, so is possible apply the simplification in terms of length, adaptability to variations and additions. The last numbers indicate the maximum capacity of the subclass with a maximum of 99 combinations, or 99 items. By limiting the number of products, overcrowding or anomalies in the shelving system were reduce; coding becomes an additional control tool able to support the operator during daily operations. Through interoperable tools and platforms, the new information communication processes meet the aims of the project without compromising their integrity using the BIM methodology.

Data sharing and web cloud

For to improve and automate the operations of inserting and removing articles from the digital model; the data entered through the procedure described above, must relate to an external relational database that could communicate updates via query. This operation is possible with special plugin on the modelling software exporting to DB Link. This interchange format allows exporting the various elements of the BIM model and the relative information in different system for the management of data, such as the MS Access platform.
In order to be able, the manager of information flow in the warehouse, it is necessary to set up some queries to improve the visualization and the manipulation of the data. Using a primary key of the element ID code are extract from the category Generic Model all objects that have the attribute IDType equal to Pallet. Later the table created was divided according to the attributes of Situation in two additional tables that identify the busy workstations and those empty. By dividing the database into relational tables in this way, it is possible to proceed to the creation of forms that allow facilitating the manipulation of data and communicating with the values of the management system. Using the Microsoft Access platform, the interface highlight with the Fig. 3.5 could be customized with different parameters. The “Product insertion” form was able to automatically fill in the fields of Code, IR, Condition and Zone; in fact, these parameters depend on the type of article to be inserted, it was therefore sufficient to query this data and click on the “insert” button to fill in all the fields listed above in the correct way. The mask use query for to change the element properties that have as the parameter " Situation empty”. A second mask created allows you to remove products from the warehouse instead. This mask is able to select the code of the article and remove and recompile the data of the entity if the user has changed the real conditions. Once the operations on the relational database are executed, it is possible to update the digital model using the DBlink plug-in and immediately see the changes made. Once again, this methodology allows to identify the discontinuities and verified the codes through simplified procedures.

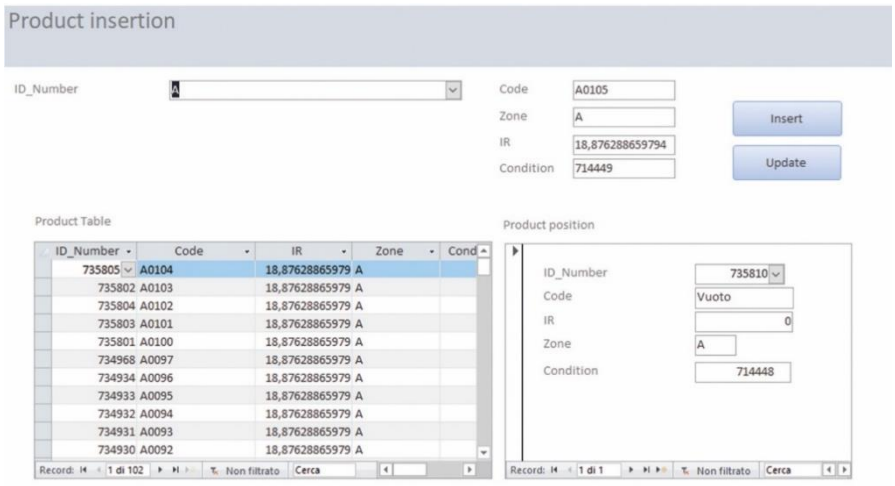


Fig. 3.5 Interface used for inserting products

The creations of this external dashboard for the data sharing, facilitated the connection on the web cloud. Indeed, the two masks transfer the same text file that the user established for the BIM model. Thanks many queries the virtual model contains all geometric and alphanumeric information's performed during the activity of the technical areas.

Interoperability between BIM model and application for Mixed Reality

Today BIM authoring platforms doesn't guarantee a direct interaction with Augmented or Virtual Reality solutions, for these reasons it is useful test the interoperability process and apply the standardization. Analyzing the different software present on the market that are open source and compatible with the BIM methodology, the attention focused on Unity 3d. This platform was born mainly for create the virtual game and only in recent years it used thanks the versatility in importing parametric models. The problems for this program, concern the alphanumeric properties associated with three-dimensional objects in fact, it is difficult to associate the information without reassigning them through a programming language. The first operation to be carried out on the BIM software is differentiate the model through two database, one strictly geometric and one informative with all the data necessary for the visualization. The only way to export the BIM model into this platform is the FBX format.

This specific extension has the possibility to keep within the three-dimensional model, the elements' hierarchy, materials and complex geometries with their coding. By analysing the nomenclature that each object keeps, it is possible to verify

the parametric family name, type and ID. In the first step, the information database must be structured considering the ID in order to export it correctly in the visualization software. The format that read correctly every information is the json. It is based on a Java programming language, that recognizing data in string, in Boolean, in variables and ordered sequence of values to which a function is associated to display additional properties. By supporting may coding such as text and number sequences, any name give at the parametric element is perfectly integrating into Unity. The information database exported is manage by Dynamo software to convert existing values into reading data with the JsonData format. Within this extension, the parameters reworked according to the selected data input, in this case study the ID number, the Condition parameter. Once the databases have been correctly importing through an appropriate script, each object is associated with a parameter corresponding to the ID and entered the necessary operations; for example, identify its position, update its condition. To speed up the system is necessary to create a list of items that to simplify the search and selection. The Unity software includes a Mixed/Reality application called Vuforia, able to associate targets or detected objects into the virtual model. Through virtual buttons, the user can interact with the Digital Model and become an integral part of the process.

4 Results

The Mixed Reality applications support daily worker's activities, meeting the challenges of the fourth industrial revolution (Quint et al. 2015).
Through headset and simple interactions, it is possible to increase and innovate the communication between different employees within the departments. It is really the optimization of communication and the experimentation of new management methodologies that transforms the tools into intelligent objects able to process large amounts of data and make them more accessible with a simple "click". This system highlights the advantages of Mixed Reality during visual inspection of intelligent objects. (Jakl et al. 2018)
Data management system is a central element in a warehouse commissioning activity, as it needs to create a database that is updatable and easy to manipulate during the daily operations. (Latif et al. 2019)
Comparing different studies, it emerged the need to provide a specific function to modify directly from the application in MXR the information on the position of the products during the phase of procurement of resources.
The result of this job brought the identification of the new innovative methods for manage directly the data using Mixed Reality's headset. Indeed, the tools of

Augmented Reality and Mixed Reality have been used in this contribution for the goods receipt with respect to the delivery note and to decide where to place and how to place the articles in the specific areas. In Fig. 4.1 it's possible to view the position of elements and their conditions, for example if the pallet contain the article or not. Selecting the zone in the application, the script shown only element into this area, so the user is facilitated to search the object.
These new technologies can help the operator to quickly identify the product during the "picking" phase. During the mentioned phase, in addition to view the product, it is also possible to communicate errors during the tracking / moving of goods, scan the barcode and assign it to the picking cart or provide information to avoid situations of overcrowding. (Stoltz et al. 2017)



Fig. 4.1 Warehouse visualization in Mixed Reality

Thanks to the great potential that emerged during the picking phase, the application in Mixed Reality developed tries to find innovative solutions to solve some of the needs highlighted above. The identification of individual products, follows the real localization, taking into the coordinates of single articles present into warehouse.
The sectorial nature of the areas of storage is based on the correct allocation of the product and the sharing of the 3d model and its database on cloud platforms define innovative method. The user could decide based on his role and the responsibilities assigned what to see, using simple buttons. In a first phase, the initial menu provides the possibility to view in video format, the entire construction process of the BIM model and the association of alphanumeric data from the management system. In addition, it is useful to analyse the effectiveness of parametric 3D visualization,

during the monitoring phases of the components present within the area. In this way, the specialized employee could be trained without any human support, simply by following a video tutorial where in detail was explained the process of implementation of management of the BIM model. Through another two buttons, once on the spot it was possible to superimpose the entire digital model to the physical one and to interrogate through tags the allocation of the goods divided by sector and identification code. Selecting the “Select Zone” button allows you to choose the area of interest and view only the pallets and racking compressed within that area. So, the user analyses the number of empty or occupied positions on the reference day selected. This data could be linked to an online database that can be modified by all the employees in the department. The advantage of being able to compartmentalization the warehouse ensures greater reliability of data, better controlling the priority of the products present or arriving, without having to carry out a second control. The second button inserted give at the user the possibility of displaying the single product in the area select, after it will light up on the virtual model and consequently, with the right over-lap with the real position, it will be easy to identify it. For this part is important to add all the information related the product and with any other commands update its position. By combining two visualizations, it was possible to make a further check on the paper information coming from the commercial area, verifying if the products were correctly positioned according to the order of exit. Specifically, in Fig. 4.2 the application allows to search for a specific product in the warehouse through a match between lists. Each table contains the list of all product codes in the department and could be compared with each individual attribute that is provided as input by the user. If the data are the same, then the match between the data is satisfied. The final output of the process makes able to extract an index used for to select the geometry corresponding and to assign the position. The ability to share the parametric model on the web and manage its properties through basic interactions provides good support to different users who use the application in Real Time. Whenever the user deletes a product or changes its allocation priority to a shared database, the application updates this information and view new content. In this way, the virtual model facilitates any overlapping of elements and allows more users to manage in an innovative way the products even in times of great criticality or overcrowding.



Fig. 4.2 Visualization of product into warehouse

Using multiple scripts created specifically to meet the needs at different stages, it is possible to recall the data of the devices in the field, cataloging and historicizing the problems in a single database. Since the first simulations, several inexpert users of these technologies have responded positively to use this new optimized warehouse management. The first results are related to the reduction of paper by leaving delivery notes and transferring the other documents to the cloud for editing in Real Time and visible by all users. The second advantage is the optimization of the storage time of the articles, as the application described above facilitates communication between paper documents and real object through the reading the identification strings. Furthermore, give the way to access at the information freely, it is possible to compare data from outside the industry or to manage the customer's request in an optimized way and to transfer correct information to other employees in the departments. In order to carry out this type of process, other partners have developed algorithms to convert the scripts used for data transmission in the departments.
Everything becomes traced in this way; creating a unique and accessible archive at any time of the day. Another important result achieved thanks to the DISLO-MAN platform is the degree of technological innovation that the companies have put in place. Every script and algorithm have been tested and stressed to the maximum level for to optimize the process also thanks to Mixed Reality applications.

5 Conclusion

By searching for advanced viewers and software it will certainly be easier to manage interactions and enter a large amount of information. Unfortunately, the limit of these technologies does not allow for a fluid and fully interoperable flow, but it was necessary to apply simplifications to the digital model or rework data, remaining as close as possible to reality so as not to change the simulated results.
The implementation of new technologies such as Mixed Reality headset directly connected to the BIM model will increase the productivity and efficiency of the factory system. In addition, new forms of investment linked to production optimization through direct control of operations will increase and reduced the human errors due to poor training and prevention. Innovating means optimizing, digitization involves a greater investment in methodologies and tools suitable for simplifying the management of a complex system both in terms of human resources and for the protection of critical data.
Increasing the BIM methodology, so far widely applied to the world of construction, in complex sectors such as Industry 4.0 means experimenting with tools that could connect the real world to behaviours and virtual resources increasingly similar to each other. The connection between these two apparently distant worlds will only happen thanks to a cultural and social change, which over the years will involve not only the industrial world but will lead to a new vision of society, going beyond current innovations. The new society 5.0 based on increasingly smart and interconnected communication methods. (Fonseca, 2018)
A viewer will no longer be enough to increase the perception and information that surround us but through avatars, we will be able to control in Real Time more sectors. Creating a shared database also allows users to implement applications with push notifications as soon as the files change so that inefficiencies can kept under control. In this moment, the applications in the industrial field that use the integration BIM-MES and VAR tools are not many.

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8 Captions

Fig. 3.1 Workflow and methodology use for innovating the industrial case study
Fig. 3.2 BIM model of case study
Table 3.1 Management indices
Fig. 3.3 Dynamo script to identify storage areas
Fig. 3.4 Overcrowding of products in the selected area
Fig. 3.5 Interface used for inserting products
Fig. 4.1 Warehouse visualization in Mixed Reality
Fig. 4.2 Visualization of product into warehouse