AR&VR for employee training

Another business need

The Challenge

Although automation and robotics can help fill some of my production activities due to lack of financial resources I still need employees to work on the traditional machines such as lathe machines, milling machines etc. The employees working on these machines are 60+ years old and are getting close to retirement and there are no young people trained for such jobs on the market. This is one of the biggest threats facing the manufacturing sector today.

Main Requirements

N/A

Other Requirements

N/A

Key Performance Indicators

N/A

Industry Sector:
Manufacturing

Challenge classification:
N/A

Time for Project Completion:
N/A

Other informations

N/A

Research Phase

Taking into account the challenge description, its requirements and its information, elaborate at least 5 questions that can lead your research for a solution.

Research questions:

1. How can traditional machines (e.g., lathe machines, milling machines) be retrofitted in such a way that they can be operated by young employees?
2. How can the cost of automation and robotics be reduced so it is affordable for small production activities?
3. How can young employees be upskilled so they are able to operate traditional machines?
4. How can the procedures associated with the operation of traditional machines be documented so future generations can take advantage of the know-how and experience of those that went before?
5. Are there any low-cost alternatives to traditional machines (e.g., lathe machines, milling machines)?

Given the questions and the main requirements of the challenge previously listed:

- *identify possible technologies using the Planet4 Taxonomy Explorer;*
- *identify and analyze the sources (papers, articles, etc.) of those technologies that best suit the challenge;*

Technologies identified in the taxonomy:

1. Fully Automated Production Facilities
2. Legacy Systems Modernization and Retrofitting
3. Remote Operation
4. Employee Training and Assistance in Worker's Tasks
5. Knowledge Management
6. Cost and Number of Parts or Components Reduction
7. Simulation software
8. Virtual Reality
9. Augmented Reality
10. 3D Printers
11. Offline Robot Programming and Simulation
12. Databases
13. Usability Improvement
14. Mass Customization

Sources of those technologies that best suit the challenge:

1. https://www.sciencedirect.com/science/article/pii/S2212827119312831
2. https://www.scopus.com/record/display.uri?eid=2-s2.0-85106664483&doi=10.3390%2fpr9050864&origin=inward&txGid=711beb5bfbf3d816a5f04aae54bdb022&featureToggles=FEATURE_NEW_DOC_DETAILS_EXPORT:1
3. https://www.sciencedirect.com/science/article/abs/pii/S036083521930662X
4. https://www.scopus.com/record/display.uri?eid=2-s2.0-85099811893&doi=10.1016%2fj.promfg.2020.10.012&origin=inward&txGid=50d65032c7997078427c7d3b9b8b0795&featureToggles=FEATURE_NEW_DOC_DETAILS_EXPORT:1
5. https://link.springer.com/article/10.1007/s00170-019-03801-3
6. https://link.springer.com/article/10.1007/s00170-020-05997-1
7. https://ieeexplore.ieee.org/document/9367549
8. https://www.sciencedirect.com/science/article/pii/S2212827119306080
9. https://www.sciencedirect.com/science/article/pii/S2212827119301714
10. https://ieeexplore.ieee.org/document/9262203
11. https://www.iaarc.org/publications/2019_proceedings_of_the_36th_isarc/direct_write_fabrication_of_wear_profiling_iot_sensor_for_3d_printed_industrial_equipment.html
12. https://www.mdpi.com/2073-4360/13/2/309/htm
13. https://www.mdpi.com/2071-1050/13/18/10441
14. https://www.researchgate.net/publication/280722890_Reducing_Complexity_with_Simplicity_-_Usability_Methods_for_Industry_40
15. https://peerj.com/articles/cs-629/
16. https://jmeche.uitm.edu.my/wp-content/uploads/2019/08/10%20ID212%20Final.pdf
17. https://www.redhat.com/en/blog/industry-4-and-ot-transformation-technologies-benefits-and-challenges

In light of the discoveries made:

- *report the answers for the questions above;*
- *compare 2-3 of the more common solutions identified in the sources (how would they change the approach to the solution? What are the possible benefits/issues in such a use of these technologies?);*
- *draw initial conclusions on which path you want to take in proposing a solution.*

Answers:

1. There are two main strategies to retrofit existing production machines: either using modern 3d printers to build complex machinery parts or using intelligent automation systems (that could be supported by a Digital Twin) to automate (and oversee) the operation of the production machine.
2. According to the literature, it is possible to increase the efficiency of manufacturing networks by conducting a “cloud-inspired” resource sharing. That is, the cost of operation and maintenance of machinery is shared by different users according to the usage of each user.
3. Using Virtual and Augmented Reality it is possible to systematically train young employees on the

operation of traditional machines. These technologies enable their users to be exposed to different predefined situations that could strengthen and speed-up their learning process.

4. Document-oriented data repositories as well as digital courses (based on Virtual and Augmented Reality) could result in a convenient solution to store all the know-how associated with the operation of a traditional production machine. These digital courses could be live entities that could be enhanced with the experiences that arise day-to-day.
5. In recent years, 3D printers have dramatically reduced the cost of production machinery, especially taking into account that 3D printers themselves can print other 3D printers as well as production machinery.

Comparison:

Overall, according to the findings in the literature, there are three main strategies to address the challenge:

1. Machinery retrofitting
2. Machinery modernization
3. Workers reskilling

Machinery retrofitting requires the development of an ad hoc solution for each machine, which could result in an expensive solution but would still keep the machine in operation with very down-time in the manufacturing pipeline.
On the contrary, modernizing traditional machinery with the newest 3d printers would reduce the amount of specific knowledge that workers would need to operate the machine, but (1) it could add some down-time to the manufacturing down-time, (2) there might be some pieces that are difficult to build with a 3d printer, and (3) the price of a 3d printer might be a solid barrier for some factories.
Finally, it could be possible to build an immersive training hands-on course enabled by Augmented and Virtual reality that could store the experiences and know-how of current machine operators forever. Building this course could be considerably time-consuming but their benefits in the long-run would be notable.

Conclusions:

To address the challenge of avoiding traditional production machinery to become obsolete—due to the lack of workers with the necessary knowledge to operate them—in a cost-constrained way, three different alternatives can be identified in the literature.

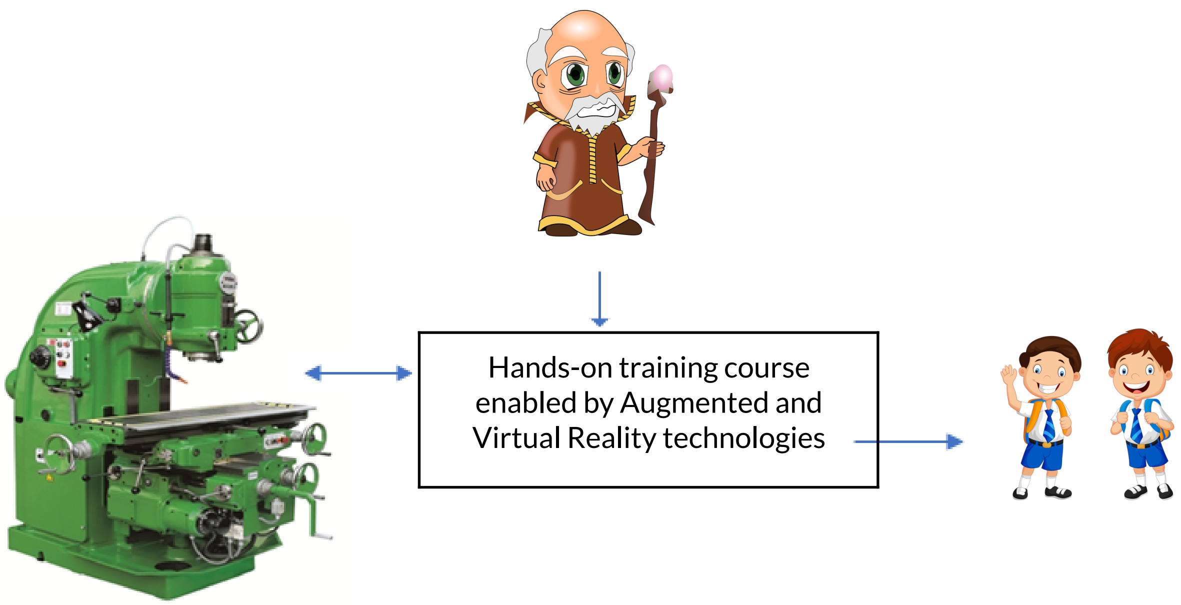
The first alternative consists of automating the operation of machinery by installing low-cost physical add-ons and developing a digital twin able to oversee the production. The second alternative consists of using 3D printers to conduct these production activities; which young generations of employees are potentially more accustomed to using. The third alternative consists of creating digital training courses (so they are reusable and enhanceable over time) on how to operate this traditional machinery. These training courses could be best seen as a live operating manual in which, with the help of Virtual and Augmented Reality technologies, students could be exposed to the different key situations that are necessary to learn and understand the operation of the machinery.

Proposed Solution

Making use of the technologies identified after the analysis of the sources, describe a possible solution to the challenge. Also, do not forget the constraints (time, number of devices to produce/connect, etc.): the solution must be applicable to the real context of the company that commissioned the challenge.

Solution Summary

Taking into account the budget constraints posed by the challenge definition, the proposed solution consists of building an ad-hoc hands-on course committed to train young engineers on the operation of traditional machinery. This training course will be enabled by Augmented and Virtual Reality technologies that will help students (and trainers) to rapidly and effectively acquire (and convey) the learning outcomes.



Solution Description

The internal core of the solution relies on the Augmented and Virtual Reality technology. On the one hand, the operation and models of the traditional machine will be digitized to be run in a single computer. Then, the learning path and outcomes will led to the definition of the training scenarios. The initial training scenarios will be using 100% Virtual Reality (VR). As students progress on the course, Augmented Reality will take a relevant role, so they will move from an environment 100% virtual in front of a computer to an Augmented scenario where students will start interacting with the physical machine in the real-world and, with the help of VR glasses, they will learn the effects of their interaction with the machine. Finally, the augmented scenario will lead to a real-world real-operation scenario in which students will show that they have successfully mastered the operation of the machine.

Implementation Plan

The implementation plan is composed of 4 stages, each stage having an associated milestone:

- STAGE 1: Definition of learning path and identification of the main learning outcomes of the training course. At this stage all the possible scenarios in which students have to be exposed to ensure their successful training have to be defined by the operators of the traditional machines.

Milestone 1: Learning Scenarios definition.

- STAGE 2: Selection of the most appropriate Augmented and Virtual Reality technological tools to convey the course. At this stage, the following will be considered: technologies and gear set used by students (e.g., VR headsets, smart wristbands, ...), software to program the scenarios of the training course (e.g., Unity), hardware resources to run the training course (e.g., computer desktop with GPU).

Milestone 2: Hardware and software requirements to implement the course.

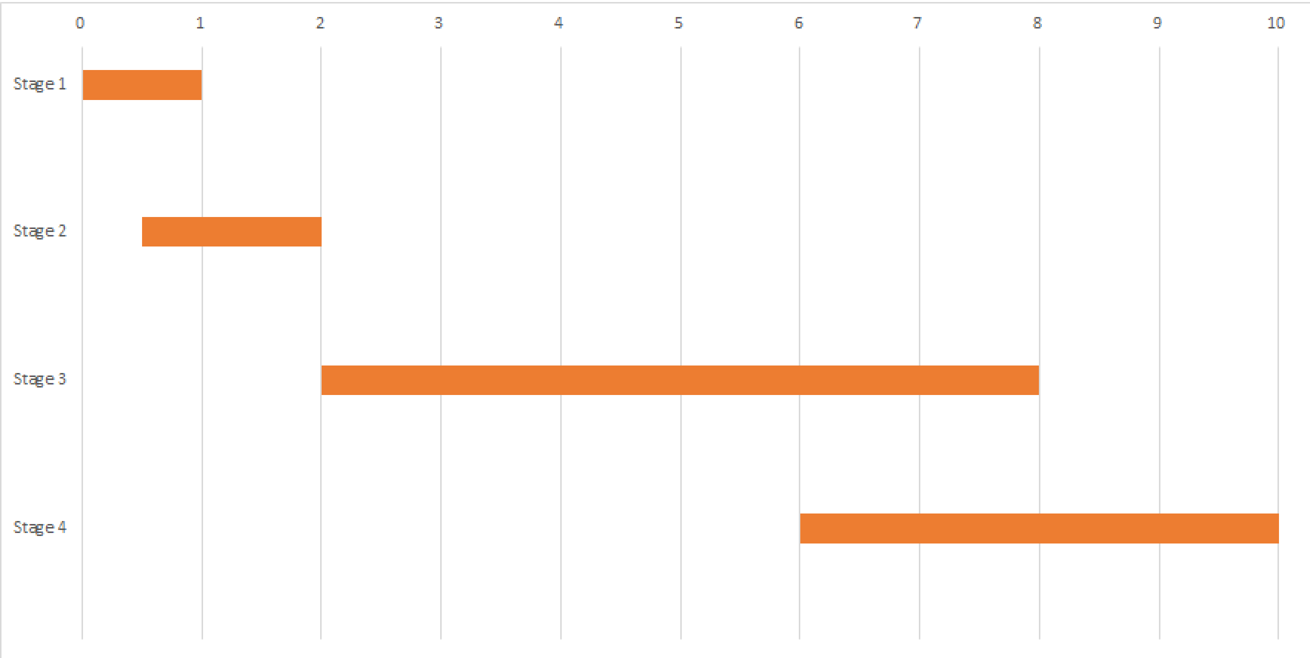
- STAGE 3: Course implementation. At this stage, all the scenarios defined in STAGE 1 will be implemented using the technologies defined in STAGE 2.

Milestone 3: First beta version of the training course

- STAGE 4: Course testing. At this stage, the training course will be tested and validated by a reduced set of users to identify possible bugs, issues and shortcomings that will contribute to refine the course implementation.

Milestone 4: Final version of the training course.

Gantt chart:



High-level cost analysis

Augmented Reality and Virtual Reality gear set	1,000 €
Hardware resources	1,500 €
Programming training scenarios	20,000 €
TOTAL	23,000 €

Possible difficulties:

1. The scenarios proposed by the current operators of the traditional machine might be difficult to translate into a computer programming environment.
2. The training path might be difficult to define for someone who did not learn to use the machine using Virtual and Augmented Reality.
3. Some students/trainers might be reluctant to use Virtual/Augmented reality.

Possible opportunities:

1. Students can learn without the danger/fear of being harmed by the machine.
2. The digital course does not depend on the individual knowledge of the worker, which ensures its long term sustainability.
3. The course can be sold to other companies using the same machinery.