Application: CAD/CAM Systems

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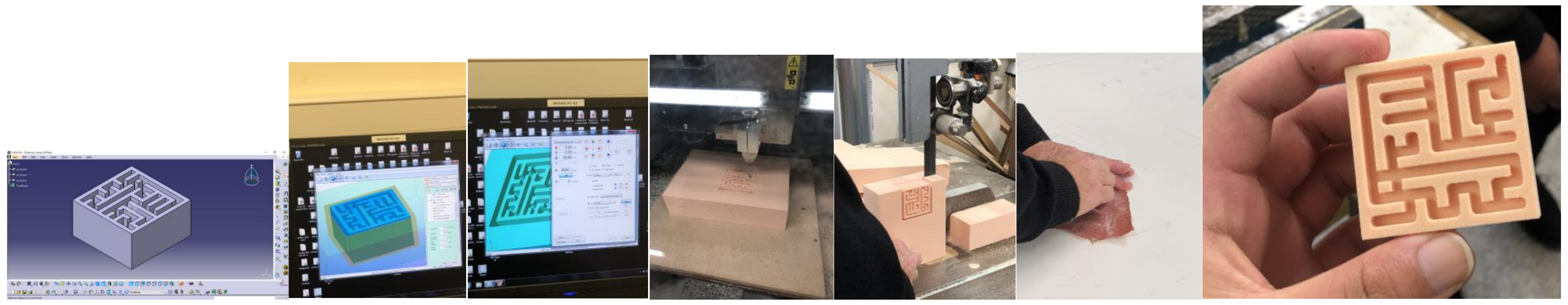
**Description of the Lab activity**

- Brief description of the lab activity and task given to you
  My task was design a ball bearing puzzle game of my choice, considering the constraints (size maximum 50*50*40 width*Length* Height, Bal bearing size 3mm, Machine tooling capabilities, 3D printer size and capabilities). I needed to start with the design first with creating a fully constraint sketch and make it into a 3D solid design using CAD software called CATIA. The design would be made using CAM software called SRP player and hardware called CNC Milling Machine.

- The exercise out put
  In the labs, I started with sketching the foundation of the maze in CATIA, length and width, 50*50. I then sketched the maze on top of the foundation, carefully considering the constraint between each wall which was minimum 3mm, I made it 3.2 so that the ball would roll easily. After I made all wall thickness 3mm, so that the CAM machine cutter would be able to precisely cut the walls. Finally, I lifted the height by additional 20mm + the height of the sketch was 6mm, making the total height 26mm. Next part was to save the file as an STL file so that it could be imported into the SRP player, so that correct measurements can be inputted and then the maze was ready for cutting. SRP Player needed to be configured because of the material and cutter limitation. Material used was Styrofoam which means that the wall thickness had to be 3mm minimum otherwise the wall would break, also the cutter was 3mm maximum which meant it could not make less than 3mm. Therefore adjustments and measurements had to be entered in the SRP player to create a toolpath for the Rolland CNC Milling Machine to cut the Styrofoam into the Maze design that I made in CATIA. The values entered to create were the same constraints that was in CATIA. After all the values were entered and applied, the machine started cutting the Styrofoam for about 45 minutes and finished. After that the remaining part, not needed of the material needed to be cut off and then edges needed to be smoothened.



- Challenges
  One of the challenges that I faced was using CATIA for the first time. I had never used CATIA before and it took me 2 weeks to get used to it. First steps was getting used to the sketching side of it, secondly was setting constraints for the sketch and thirdly fixing the errors. I learned how to navigate through CATIA by doing the lab tasks. It sort of prepped me for the Maze design I chose to do, as it showed me how to start with a design, how to enter sketch mode and how to exit, how to set the constraints and everything had to be constrained to be padded. Second challenge that I faced was designing the Maze puzzle in CATIA. I could not do a complicated maze as it would have required smaller cutter than a 3mm, because of this I had to make sure that I had to work inside the dimensions I was given. When I started sketching, I started off with picking the rectangle instead of a line because line would have been harder to constraint and more time consuming. Therefore I picked a rectangle sketch for each wall that I was sketching and constraint it with each other bearing in mind that wall thickness constraint and wall distance constraint had to be equal, so that the overall constraint would be equal to 50*50*26. This gave me a big problem as I erased some sides of the rectangles, giving me errors that the other sides were already constrained when I didn't, this meant that it had automatically assumed to take the broken sides were automatically matched with the constraints of other triangles which meant that if I moved one rectangle, every rectangle constrained with it would also move. I overcame this challenge, by firstly sketching a triangle where needed and constraining the rectangle before cutting therefore only having to erase sides that were not needed, if needed to add more sides then I would sketch a line, rather than a rectangle, making it more easier to constraint.

**Benefits to industry**

- Identify the issue this application could improve
  CAD is Computer based tools (software) that aid the Design process of 3D model, Drafting, Analysis FEA, simulation and CAM is Computer based tools (software and hardware) that aid the manufacturing process of process Planning and verification, part production and Assembly. Using CAD/CAM systems could significantly improve the development process. (Abdelaziz, 2016)

  Historically product development has involved two divided process: designing the product and manufacturing it, just like my maze puzzle. This means that there is always two tools used CAD/CAM and they are not integrated together, this has caused communication barrier between design and production, resulting in cost, time and quality issues, disruptions arise when changes needs to be made to the manufacturing, by using an integrated CAD/CAM solution, you can overcome the problems associated with the traditional disconnect between design and manufacturing. With an integrated CAD/ CAM platform, you can reduce cycle times, control costs, and improve quality.

  Integrated CAM/CAM is a CAM solution that uses a CAD system as its front-end, geometry engine. Instead of importing or converting a CAD file, or some other data format, such as IGES or STEP, an integrated CAD/ CAM platform performs CAM operations on the CAD file itself, offering full single-window, bidirectional associativity between the CAM application and the CAD system. This technological advance offers many advantages that can help you boost productivity, control costs, and resolve manufacturing issues. Companies have already seen 50% improvement in manufacturing productivity. Since implementing an integrated SOLIDWORKS® CAD and BobCAM for SOLIDWORKS solution, Texas Chassisworks has realized a 50 percent improvement in manufacturing productivity. Based in Tyler, Texas, the company produces high-end drag-racing cars and associated parts. Prior to implementing an integrated CAD/CAM solution, Texas Chassisworks had to convert designs to IGES files, and then import them. This approach resulted in multiple operations that were time consuming. With BobCAM for SOLIDWORKS software, a certified, integrated CAD/CAM solution for SOLIDWORKS, the company can apply CAM operations directly to the SOLIDWORKS CAD model and use advanced tool-path operations to decrease cycle time by 50 percent. (DS, 2014)

  By using an integrated CAD/CAM, there is one model supporting in both design and manufacturing functions instead of having various file formats, numerous data translations/conversions, and different CAD/CAM Model. The CAD model becomes the sole geometry in play. The single model paradigm breaks down the communication barriers by working with same data and speaking the same language. All design changed will be updated automatically to all associated tool paths and drawings saving time-consuming and costly effect towards improving issue of the development process.

- How it will impact on the product/production life cycle

  CAD/CAM integration enables a concurrent, collaborative approach to design through manufacturing, which improves communication and quality, and saves time and money. This will have an impact on the product/production life cycle by pre-production iterations, which means resolving design for manufacturing issues prior to production, which is more efficient than after a design is released for production. Also working with the same model and data format with no need to import or translate or convert data, this eliminates the chances of errors and maintains high levels of accuracy and minimizes delays relating to design errors. This is very different from the current product/production life cycle because it is making the development process of the product and production faster by eliminating the need for transferring data and work as a single model which saves time, contributing effectively better in terms of cost, quality, development and production. (DS, 2014)

**The product/production life cycle**

- Where in life cycle and how can it be integrated with the previous and following step in the life cycle
  In a typical product/production life cycle, the steps are: Product concept → Design Engineering → Drafting → Process Planning → Order New Equipment & Tolling or Production Scheduling → Production → Quality Control → Customer & Market.

  CAD/CAM can be integrated with the previous step in the life cycle by adding: Computer aided design, Computer automated drafting & documentation, Computer aided process planning, Computer scheduling, material requirements planning, shop floor control, Computer controlled robots, machines, etc., Computer aided quality control. Therefore the whole revised system would look like: : Product concept → **Computer aided design** → **Computer automated drafting & documentation** → **Computer aided process planning** → Design Engineering → Drafting → Process Planning → **Computer scheduling, material requirements planning, shop floor control** → Order New Equipment & Tolling or Production Scheduling → **Computer controlled robots, machines, etc.** → Production → **Computer aided quality control** → Quality Control → Customer & Market. (vask82, 2015)

- The common characteristic that describe the application
  - Computer graphic work station contains Hardware/Software, Graphic input - Design parameters and Machining parameters, Graphic display – Stock and part, Graphic Processing -Tool path and Process simulation.
  - Common database contains Data Storage of Standard Format and Security, Data Communication of Hard drive and Wireless, Group Technology like Common parts and Tasks.
  - Numerical control of the machine which consists of an input interface, Instruction Logic (G Code), Memory and an output interface.
  - Automated material handling including material storage and retrieval using: Robots, Conveyer, PLC, Sensors and automated guided vehicles AGV. (Coventry University , 2016)

- Identify important attributes which affect the application, for example format of information sharing
  CAD/CAM can be affected by hardware/software. For example I started to do my Maze design in university computers. Everything was pre-configured with settings, so it worked smoothly and without any errors or lags, however when I tried to do the project in my personal computer, CATIA opened slower and project was loaded and majority of times not responding. This was because my laptop is about 7 years older and the specifications of my laptop just couldn't handle the specifications required to run CATIA. It can also be affected by other software's, if one or more software is running while CATIA is running then there isn't enough memory to allocate to CATIA as operating systems tries to give each application opened the same memory, this can cause CAD software to crash. CAM system can be affected by the compatibility of the CAD file, if the file is corrupted or measurements are not correct for the CAM system.

**Reflection and conclusion**

- Reflection on how the application can impact on industry 4.0 and the digital engineering environment
  Companies are now moving towards more integrated CAD/CAM system, this is certainly a good thing as this means that CAD/CAM software are now offering well documented API's for integration and automation, this means that it could be possible to automate new tasks that was not possible before Industry 4.0. This is likely to result in more investment from big corporate companies to start smart factories all over the world that will integrate both worlds, virtual and physical. This is going to have a big impact on industry 4.0 and the digital engineering environment because the industry was suffering from investment and change, however it is changing now where manufacturers and machines will share information with wider scope of supply chain and new systems where processes can be self-optimised, self-configured with the help of smart systems like artificial intelligence to complete complex tasks based on stronger data flows. This means there is a new possibility that there could be more than just integration of new CAD/CAM system.

  This also marks as a good impact on employment and skills development. The huge investments means that there would be more opportunities such as investments in productivity, training and recruitment which could help address the employment and skills development as there is a shortfall, the UK needs 200,000 engineering graduates each year. That's double the current number joining the sector. This means that big companies would be naïve not to invest in training and recruitment so that their company may have the most skilled work force in the country. This also affects the digital engineering environment as the augmented reality market is booming at the moment and predicted to be worth $4 billion by 2018. This means that the investments are going to be huge all over the world, making manufacturing more excepting towards Robotic Solutions, which is controlled by CAD/CAM systems. This means that there will be less costly mistakes, because the systems will be smarter and more accurate leaving less flaw in the design and testing phase. Computer-aided design and simulation will have an impact as changes are relatively cheap at this stage. (Rossi, 2016 )

  In conclusion, I think this is an exciting time for industry 4.0 and the digital engineering. CAD/CAM systems are evolving as more corporate companies are now moving towards integrated CAD/CAM systems because the market is getting more and more competitive and where customer demand is very high and they are not very patient. This is forcing the companies to invest on better systems so that they stay competitive in the market. This means that the industry is getting more investment on RND which is innovating systems into being faster and efficient. Booming products like augmented reality demands a good CAD/CAM systems and as well as complex algorithms which is why AI is being heavily invested because they are faster and automated. All this factors is helping the industry 4.0 and the digital engineering environment to come out of its limitations and opening new endless possibilities.

- Implementation requirement hardware
  Resource efficiency - Apart from the high costs, manufacturing will cost a lot of raw materials and energy, and it will pose a great threat to the environment. Therefore it will be necessary to calculate the additional resources that needs to be invested in smart factories and potential savings generated.
  Work Organisation and design – The new factories will be all advanced and smart therefore the workload and the role of the employees will change significantly. Therefore there needs to be a participative work design and learning measures where the employees would enjoy opportunity of greater responsibility and enhance their personal development.
  Training and continuing professional development: The new machines and systems like CAD/CAM will radically transform worker's job and competence profiles. It will be therefore necessary to implement an appropriate training strategies and to organise work in a way that it enables them to learn at their own pace and pursue lifelong learning. To achieve this, model projects and "best practice networks" should be promoted and digital learning techniques should be investigated. (Acatech, 2013)

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