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SD502435

Integrating AI-ML with Autodesk Fusion 360 & Autodesk PLM

Deepali Pulate

Suraj Meshram

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Learning Objectives

- Apply automation techniques to your designs and daily workflows to save time and effort, Learning New techniques
- AI/ML, adopt efficient ways to work on complex assemblies and data, Data management, New or efficient Technologies
- Cost and time effective Design, optimizing existing business services, Increasing revenue
- Increasing customer satisfaction, offering differentiated digital services, Automating business operations

Description

In today's world to design any product, we need two major things, Input and Software. We already have a software which can help in designing a product and input comes from the OEM which wants the product. What if we have a database which is having an input, what OEM is providing. With the help of AI-ML we can create an ecosystem which will fetch the exact data from PLM and import it in Fusion 360. This will help in reducing the extra man hours and cost for building any product.

By way of illustration Consider creating a car seat in the automotive business. H Point, Range for recliners, Track, and Height Adjustment are all major factors to consider while designing a seat structure. When the appropriate inputs are given, there are significant Tier 1 providers with vast amount of data that can assist in locating the correct seat. Consider integrating PLM with AI/ML, which can help reduce the amount of effort/time/money necessary to build the seats and to improve the product further.

About the Speaker(s)

LinkedIn

Deepali Pulate is a Mechanical engineer and currently working as a SQA Engineer in Fusion 360. Started her professional journey with Dassault Systems from 2016 and then later joined Autodesk in late 2021. She has worked on different CAD software in her professional life like - Catia, 3Dexperince, SolidWorks, Inventor, Fusion 360, AutoCAD, SmarTeam, 3Dviewer, Auto Vue, etc. Currently Learning and working with AI-ML Models.
She has always been fond of innovations and innovative ideas, Learning and giving it back to the society with sustainable outcomes which can bring peace and harmony. Her moto in life is - new thinking New Possibilities and believes that Miracle is another name of Hard work.

Suraj Meshram is a Research Scholar in the Centre of Excellence in Artificial Intelligence at IIT Kharagpur. He has done his master's from IIT Delhi in Mechanical Design. He has worked on the different Designs of Mechanical components, Friction and wear of bearings. He has hands-on experience in Modeling software such as Autodesk Inventor, SolidWorks and Catia. His current interests are more derived from the use of AI-ML techniques in the applications of the Mechanical domain. He is currently working on the deployment of Deep Reinforcement learning models for the balancing of Assembly lines in Flexible Manufacturing Systems.

Chapter 1: Introduction to AI

Objectives Discussed

- ***Understand how to apply Automation techniques to your daily workflows to save time and efforts, Learning new techniques***

1.1. Artificial intelligence meets project management

Before Applying Automation techniques to daily workflows, first we must have clear understanding of the challenges/Problems in existing ways and goals should be pre-Defined. It all comes down to how we look at it. Think of AI as a tool to help do your job better. It can save tons of time by curating and validating large volumes of data. Giving an example – There are lots of projects that are already been implemented in past and we have the detailed data whether it got succeeded/Failed and more. So, for future projects will get the predictable results even before the project starts with the help of AI-ML Model.

Artificial intelligence can help you make better decisions. Before the project is officially approved senior leadership and sponsor must make a myriad of decisions. These include things like initial versus ongoing investment, make versus buy, risks versus rewards, economic trends, and forecasts. On a major project this can be a time-consuming process. AI can assist by providing realistic data based on intelligence from similar past projects. This has a way of allaying many of the concerns that could delay approval. Also, it enables senior leaders to select projects that have a higher likelihood of success. Another aspect of initiating projects that AI can help with is making better predictions. It is already being used by banks for credit scoring to calculate the likelihood you will pay your loans on time. You see AI emphasizes rules-based decisions and predictive justifications rather than discretionary based decisions and intuitive justifications. In this way it can provide deep data driven insights senior leaders need to determine things like high level project parameters, interdependencies, and projections. And finally, AI can help kick off projects. How? Well one of the major purposes of a kickoff meeting is to get stakeholders engaged so they share their opinions and feedback. AI can capture what is being said. Software and apps exist today that can record multiple voices in a meeting and accurately transcribe them. AI can then analyze this information in greater detail and pull-out valuable insights based on predetermined criteria. Later can use these insights to determine what actions need to be taken. Organizations that

adopt artificial intelligence early and move forward decisively will benefit the most. And before we know it AI will be a standard part of projects, much like spreadsheets and scheduling software are today.

- Decision-making
- Predictions
- Project kickoff
- Meeting notes and analysis

Enables you to streamline planning such as collecting requirements from stakeholders, tracking assumptions, and archiving business documents and agreements. It can even delve in the previous projects and search for lessons learned to help come up with more realistic schedule and budget estimates. And as artificial intelligence progresses it will be able to take over the work partially or fully of allocating resources, analyzing risks and planning risk responses.
The future is brightest for those who evolve with these trends rather than chase after them.

1.2. Harness the power of AI

According to McKinney global institute, AI Value creation by 2030 will be $13 trillion and it is growing faster. The impact of AI builds up over time, gathering pace after five to ten years. In aggregate, and over time, the impact of AI is likely to accelerate, boosting productivity growth. Therefore, companies and countries with proactive AI strategies will likely need to be committed for the long haul, because the total net impact may become visible only after a few years

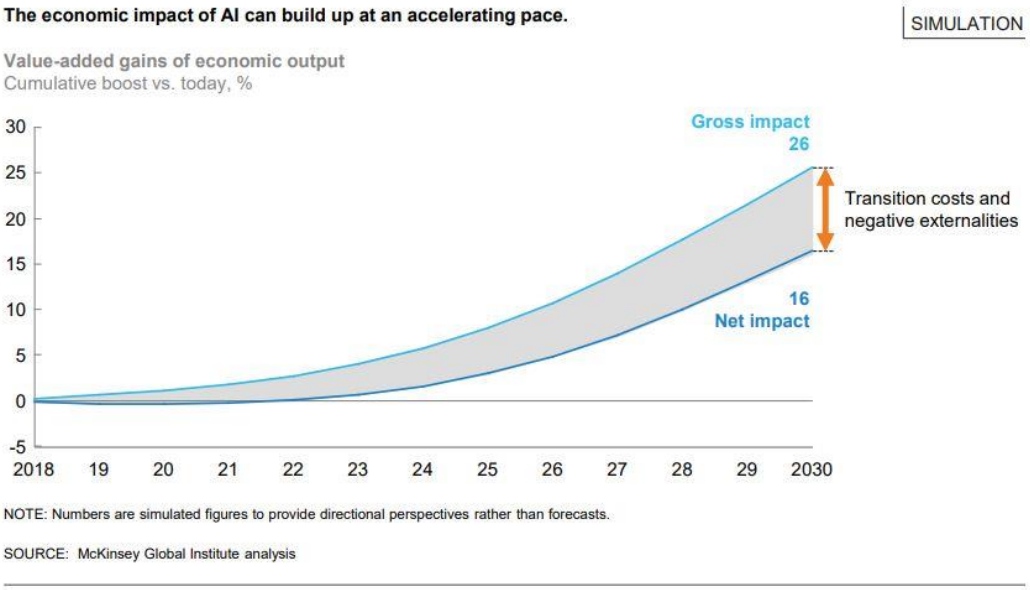

Figure 1: The economic impact of AI can build up at an accelerating pace

AI is two separate ideas, refer the following flow chart. So currently whatever the growth we are seeing in AI is ANI and not AGI.

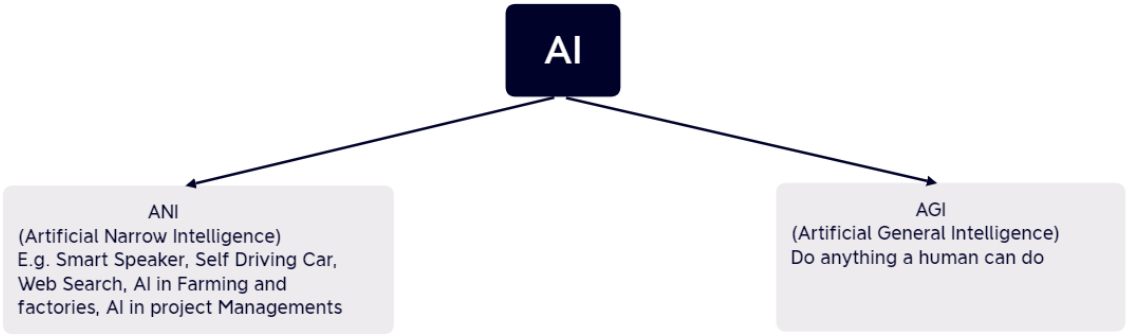

Figure 2: Classification of AI

AI/ML, adopt efficient ways to work on complex assemblies and data, Data management, New or efficient Technologies.

It is no secret that data is an increasingly important business asset, with the amount of data generated and stored globally growing at an exponential rate. Of course, collecting data is pointless if you do not do anything with it, but these enormous floods of data are simply unmanageable without automated systems to help. Artificial intelligence, machine learning and deep learning give organizations a way to extract value out of the troves of data they collect, delivering business insights, automating tasks, and advancing system capabilities. AI/ML has the potential to transform all aspects of a business by helping them achieve measurable outcomes.

Chapter 2: Methodology

Objectives Discussed

- ***AI/ML, adopt efficient ways to work on complex assemblies and data, Data management, New or efficient Technologies***
- ***Cost and time effective Design, optimizing existing business services, Increasing revenue***

Idea of the project is explained with the help of very basic Mechanical component in any Mechanical system that is bolt. While selecting specific type of bolts for specific application one must go through lot of design processes and calculations. What if we are getting a predictive result which simplifies this design process and speed up the project. Divided this project into five stages as follows

- Data Generation
- Data Pre-Processing
- Training and Test Data set
- AI-ML Model
- Model Deployment

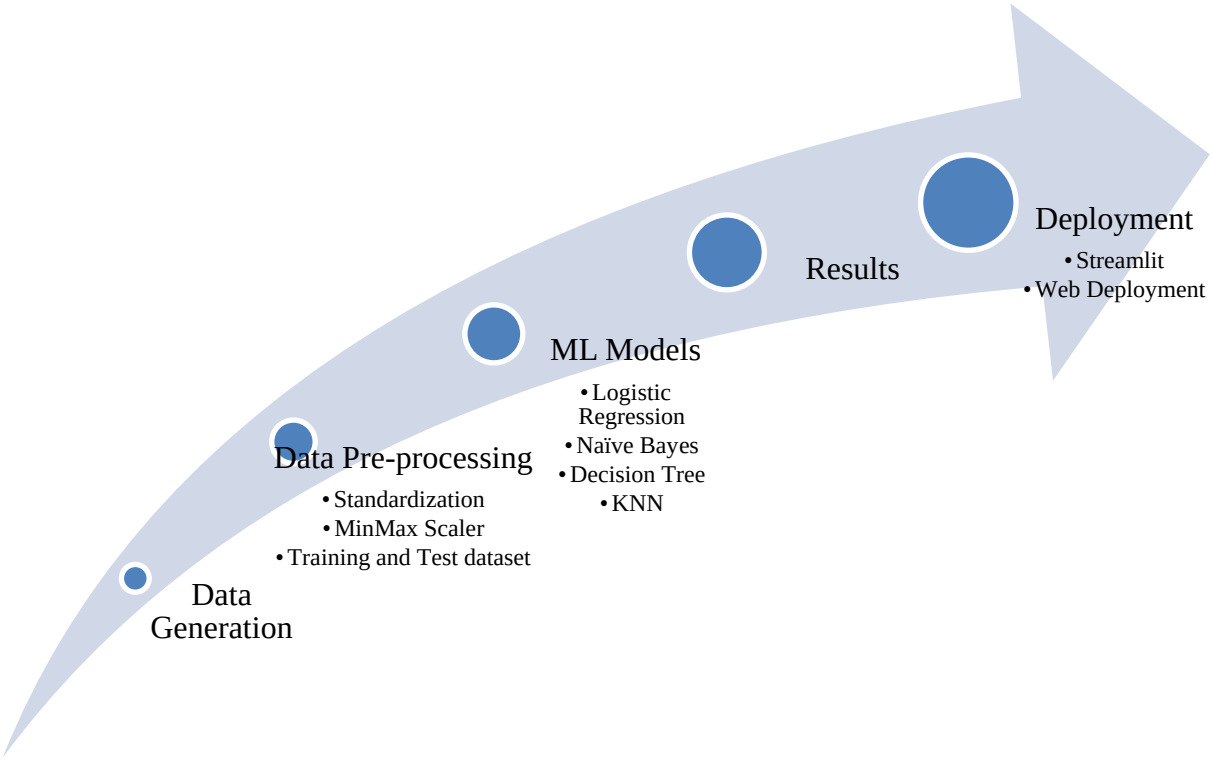

Figure 3: The proposed Methodology

2.1. Data Generation

There are different types of bolts, and it differs to what type of application for which we are using.

What is Bolt?

A bolt is a type of threaded hardware fastener that is used to position two workpieces in specific relation to each other. Bolts come in several configurations for their application and specification variances.

Since the terms "bolt" and "screw" were in use before the advent of easily produced helix fasteners, they are often synonymous, to differentiate the terms, that it is not the devices which are different, but how they are used. As provided by Machinery's Handbook and ASME B18.2.1, bolts are externally threaded fasteners that are prevented from being turned during assembly but are positioned or released by torquing a nut. Screws are externally threaded fasteners that can be inserted into pretapped holes or can perforate a material and create their own internal threads.

Bolts Components:

The components that form a bolt can be identified in three sections.

1) **Head:** The head is the part of the bolt with the largest diameter, which provides a mount for tools to either apply or resist torque. It also provides part of the bearing surface for substrates being bolted.
2) **Shank:** The shank of the bolt is the longest part of the bolt and has external, helical threads on its circumference. This piece is responsible for the alignment of the workpieces.
3) **Chamfer:** The end opposite of the head is known as the chamfer, which provides a slightly beveled edge to aid the bolt's insertion into holes and nuts.

Figure 4: Bolt Components

There are different types of Bolts, for Our Design we have selected **Hexagon Head Bolt** :

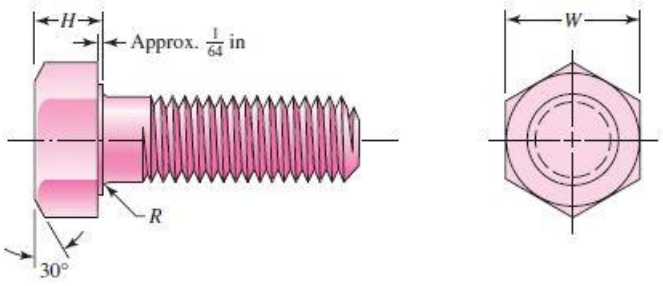

Figure 5: Hexagon Head Bolt

Bolts And Threads Dimensions:

The dimensions of a bolt can be expressed in metric or imperial units.

- ***Pitch***–distance between adjacent threads. Reciprocal of threads per inch
- ***Major diameter***–largest diameter of thread
- ***Minor diameter***–smallest diameter of thread
- ***Pitch diameter***–theoretical diameter between major and minor diameters, where tooth and gap are same width
- The ***lead***, l, is the distance the nut moves parallel to the screw axis when the nut is given one turn
- Multiple threads are also possible

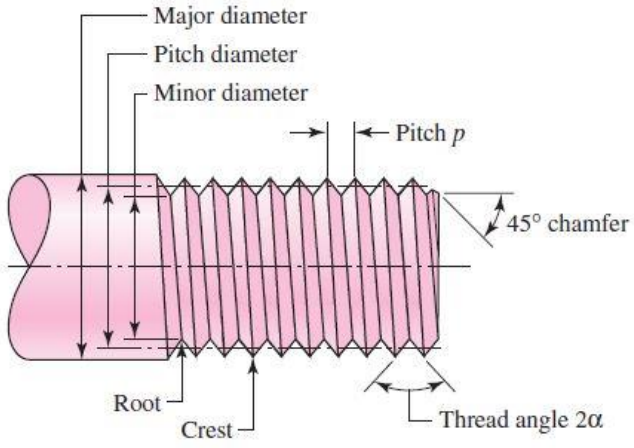

Figure 6: Bolt & Thread Definition

Standards:

The American National (Unified) thread standard defines basic thread geometry for uniformity and interchangeability

- American National (Unified) thread
    - UN normal thread
    - UNR greater root radius for fatigue applications
- Metric thread
    - M series (normal thread)
    - MJ series (greater root radius)
- Coarse series UNC
    - General assembly
    - Frequent disassembly
    - Not good for vibrations
    - The “normal” thread to specify
- Fine series UNF
    - Good for vibrations
    - Good for adjustments
    - Automotive and aircraft
- Extra Fine series UNEF
    - Good for shock and large vibrations
    - High grade alloy
    - Instrumentation
    - Aircraft

Note: For Our design we have considered ANSI Standard Bolts and Threads.

Design a Bolt:

Giving as example, to calculate the exact size of bolts we must go through the design process as follows. Let's take an example of real time usage where we have a steel column held down by four grade 8.8 bolts cast into concrete foundation and subjected to a 250 kN design uplift force (Fig. 1). How should we figure it out what minimum bolt diameter should be? Then if we go by a traditional way of designing and picking up the bolts size from Standard bolts, is as follows

Design Tensile capacity of bolt is given by this equation:

$$F_{t,Rd} = \frac{0.9 \times f_{ub} \times A_s}{\gamma_{M2}}$$

Where:

- $f_{ub} = Ultimate\ tensile\ strength\ of\ a\ bolt$
- $A_s = Tensile\ Stress\ Area, mm^2$
- $\gamma_{M2} = Partial\ Safety\ factor$

Two commonly used grades are grade 4.6 and 8.8, Grade 4.6 is common mild steel and sometimes referred to as black bolts. Grade 8.8 bolts are higher in strength. First number refers to Ultimate tensile strength of a bolt and second number gives a multiplier to get the yield stress.

For example, grade 8.8 bolt has f_{ub} = 800 N/mm^2 and yield stress is f_{yb} = 800 * 0.8 = 640 N/mm^2.

For commonly used Standard bolts tensile area is given in below table (Fig.2)

- γ_{M2} = Partial safety factor = 1.25.
- No of bolts = 4

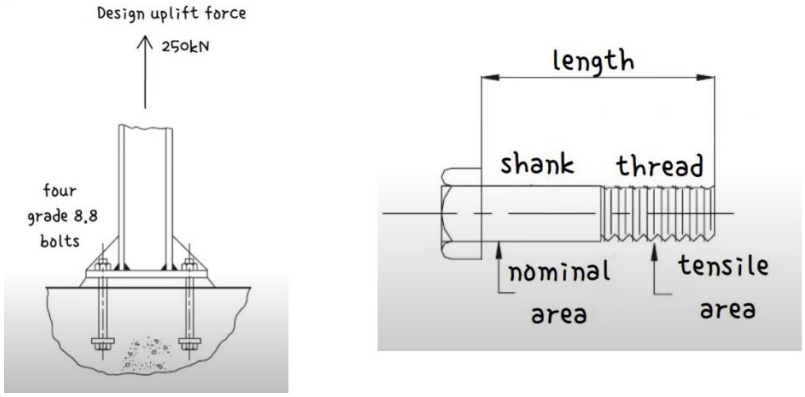

Figure 7: Foundation bolts and their structure

So, coming to the calculation of design uplift force, as we have considered number of bolts equals to 4 then,

Design uplift force will be =

$$= \frac{25000}{4} = 62.5\ kN$$

Design capacity of the bolt is given as

$$62500 = \frac{0.9 \times 800 \times A_s}{1.25}$$

Tensile stress area of the bolt is

$$A_s = 109\ mm^2$$

The required tensile area of the bolt is 109 mm2 to sustain a load of 250kN by 4 bolts. The nearest standard bolt thread available is M14 which has a tensile stress area of 115 mm2. Hence M14 bolt size is selected for the given application.

Nominal Major Diameter d mm	Coarse-Pitch Series			Fine-Pitch Series		
	Pitch p mm	Tensile-Stress Area A_t mm²	Minor-Diameter Area A_r mm²	Pitch p mm	Tensile-Stress Area A_t mm²	Minor-Diameter Area A_r mm²
1.6	0.35	1.27	1.07			
2	0.40	2.07	1.79			
2.5	0.45	3.39	2.98			
3	0.5	5.03	4.47			
3.5	0.6	6.78	6.00			
4	0.7	8.78	7.75			
5	0.8	14.2	12.7			
6	1	20.1	17.9			
8	1.25	36.6	32.8	1	39.2	36.0
10	1.5	58.0	52.3	1.25	61.2	56.3
12	1.75	84.3	76.3	1.25	92.1	86.0
14	2	115	104	1.5	125	116
16	2	157	144	1.5	167	157
20	2.5	245	225	1.5	272	259
24	3	353	324	2	384	365
30	3.5	561	519	2	621	596
36	4	817	759	2	915	884
42	4.5	1120	1050	2	1260	1230
48	5	1470	1380	2	1670	1630
56	5.5	2030	1910	2	2300	2250
64	6	2680	2520	2	3030	2980
72	6	3460	3280	2	3860	3800
80	6	4340	4140	1.5	4850	4800
90	6	5590	5360	2	6100	6020
100	6	6990	6740	2	7560	7470
110				2	9180	9080

*The equations and data used to develop this table have been obtained from ANSI B1.1-1974 and B18.3.1-1978. The minor diameter was found from the equation $d_r = d - 1.226\,869p$, and the pitch diameter from $d_p = d - 0.649\,519p$. The mean of the pitch diameter and the minor diameter was used to compute the tensile-stress area.

Figure 8: Diameters and Areas of Coarse and Fine Pitch Metric threads

If we compare the value of calculated A_s with standard Tensile area from table (Fig.4) will get Diameter of the bolt as 14mm. This was all about the traditional design process which is quite time and energy consuming. When we consider the projects on big scale where to make such types of multiple choices and selection of bolts for particular design, it will be quite easy if we use the AI-ML model to get quick responses and results with just some inputs from user.

In Automobile industry, consider designing a seat of a car. Major inputs require to design a structure of a seat like the H Point and Range for recliners, Track and Height adjustment. There are major Tier 1 suppliers with huge amount of data which can help in fetching the right seat or seat parts whenever the specified inputs are given. Consider having PLM integrated with AI-ML which can help in reducing the Efforts/Time/Money required for building the seats and can be used to further optimize the product.

The amount of data generated and stored globally is increasing at an exponential rate, making data an increasingly significant economic asset. Of course, gathering data is useless if you don't do anything with it, but these massive influxes of data are just impossible to handle without assistance from automated systems. No matter how much data we have, if it isn't usable, it won't matter how huge it is.

Organizations may gain value from the vast amounts of data they collect by using artificial intelligence, machine learning, and deep learning. These technologies generate business insights, automate activities, and enhance system capabilities. By assisting companies in achieving measurable results, AI/ML has the ability to completely alter businesses in all spheres.

Bolts will be used as an example to produce the datasets and model. The most crucial and time-consuming step in the creation of any model is data generation. Even if we have a lot of raw data, we still need to refine it and pick out the information that is actually needed. The following significant features were chosen to produce the data:

- ***Application*** - Design Uplift Force
- ***Application*** - No of bolts
- ***Material Property*** - Ultimate Tensile Strength of bolt
- ***Safety*** - Factor of safety
- ***Bolt Property*** – Tensile stress area of bolt

The output features to decide the selection of bolt is as follows

- ***Selected bolt M14*** – defines the diameter of the bolt is *14mm*.

To determine the size of bolts needed to hold the steel column, use the following table to calculate the tensile area of the bolts. We will next compare these results to the ANSI standard values of tensile area of standard bolts (Table 1).

Table 1: Table for the Data Generation process

Sr. No.	Input Data					
	Design Uplift Force (N) OR Design Tensile capacity (Ft, Rd)	**No of bolts**	**Constant value**	**Ultimate Tensile Strength of bolt grade (e.g., 8.8) (σ or fub) N/mm2**	**Partial Factor of safety = γm2**	**Tension Area = As = For Example = ((Ft, Rd/No of Bolts) * 1.25)/(0.9 * 800) (N/mm2)**
1	250000	4	0.9	800	1.25	108.51
2	500000	4	0.9	800	1.25	217.01
3	500000	6	0.9	400	1.1	254.63
4	60300	1	0.9	800	1.25	104.69

To generate large amount of data set through excel is bit difficult. So, to solve this problem we have used MATLAB to generate up to 56 lacs rows of data set with different combinations and classifiers as well.

2.2. Data Pre-Processing

Data Pre-Processing is nothing but sorting of a data. It is a process of preparing the raw data and making it suitable for our machine learning model. It is the crucial step while creating a machine learning model. When creating a machine learning project, it is not always a case that we come across the clean and formatted data. We have created 56 lacs rows with the help of, but there can be some redundancy of data, which will not help to train the model. To avoid unwanted data, we need Data Pre-Processing. Following are the points that we consider first before giving data set to train the model.

- Standardization using MinMax Scaler
- Training and Test dataset

2.2.1. Standardization and MinMax Scaler

Different characteristics in the input data contain plenty of fluctuation in the data and it will be tough for the model to converge quickly. Computation time of the training rises and also it doesn't provide better results, could obtain false positive. Range of data differs for the different characteristics; normalization needs to be done in order to decrease the data from 0 to 1. MinMax scaler was utilized to perform the standardization. It changes data by scaling characteristics to a defined range. It adjusts the values to a given value range without affecting the form of the original distribution. So, if the data under any situations includes data points distant from each other, scaling is a strategy to get them closer to each other or in plain words, we can say that the scaling is used for making data points generic so that the distance between them will be shorter.

Also, it helps to reduce redundancy and complexity by examining new data types used in the table. It is helpful to divide the large database table into smaller tables and link them using relationship. It avoids duplicate data or no repeating groups into a table.

2.2.2. Training and Test dataset

Algorithms are used in machine learning to extract knowledge from datasets. They identify patterns, gain insight, make judgments, and assess those judgments. The datasets are divided into two groups for machine learning. The first subset, referred to as the training data, is a section of our actual dataset that is used to train a machine learning model. It trains our model in this way. The testing data refers to the other subgroup. Usually, training data is bigger than testing data. This is because we want to provide the model with as much information as we can in order for it to identify and learn useful patterns. When our dataset's data are supplied to a machine learning algorithm, the programme recognizes patterns in the data and draws conclusions. You need unknown data to test your machine learning model once it has been constructed (using your training data). You may use this data, which is referred to as testing data, to assess the effectiveness and development of the training of your algorithms and to modify or optimize them for better outcomes.

2.3. Machine Learning Models

Machine learning models are algorithms that have been taught to recognize patterns in fresh data and anticipate outcomes. These models are modelled as a mathematical function that receives requests in the form of input data, processes that data to create predictions, and then returns an

output. These models are first trained using a collection of data, and then an algorithm is given to them so they may analyze the data, find patterns, and learn from the data. These models may be used to forecast the unknown dataset once they have been trained. Based on diverse business objectives and data sets, there are several types of machine learning models available.

- Supervised Learning
- Semi-Supervised Learning
- Un-Supervised Learning
- Reinforcement Learning

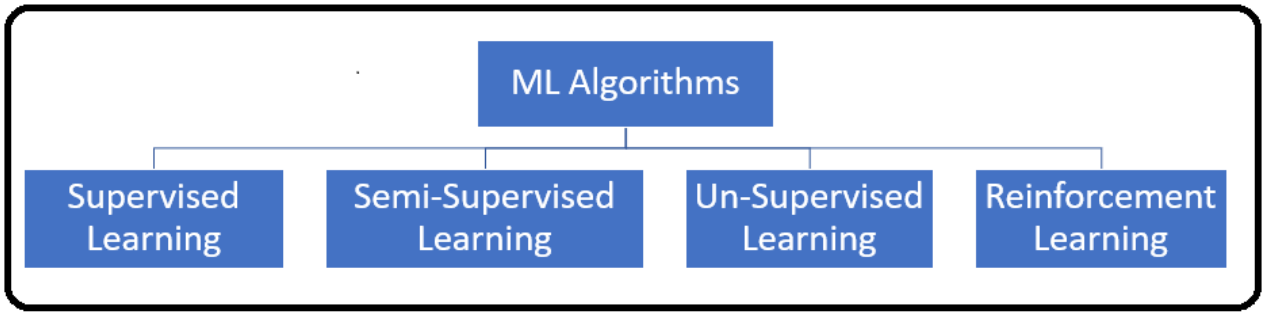

Figure 9: Classification of Machine Learning Models

Supervised Learning is the simplest machine learning model to understand in which input data is called training data and has a known label or result as an output. As a result, it operates on the idea of input-output pairs. In order to perform prediction, it is necessary to develop a function that can be learned using a training set of data before being applied to unknown data. Task-based supervised learning is evaluated using labelled data sets.

Unsupervised Machine learning models utilize unsupervised learning instead of supervised learning, allowing the model to gain knowledge from the unlabeled training data. The model makes predictions about the results based on the unlabeled dataset. Unsupervised learning allows the model to discover hidden patterns in the dataset on its own, with no outside help.

In ***reinforcement learning,*** the algorithm gathers actions for a series of starting states that eventually lead to the goal state. It is a feedback-based learning paradigm that interacts with the environment to gather feedback signals following each state or action. The agent's objective is to maximize the positive rewards in order to increase performance (Figure 6). This feedback functions as a reward (positive for each successful action and negative for each poor action).

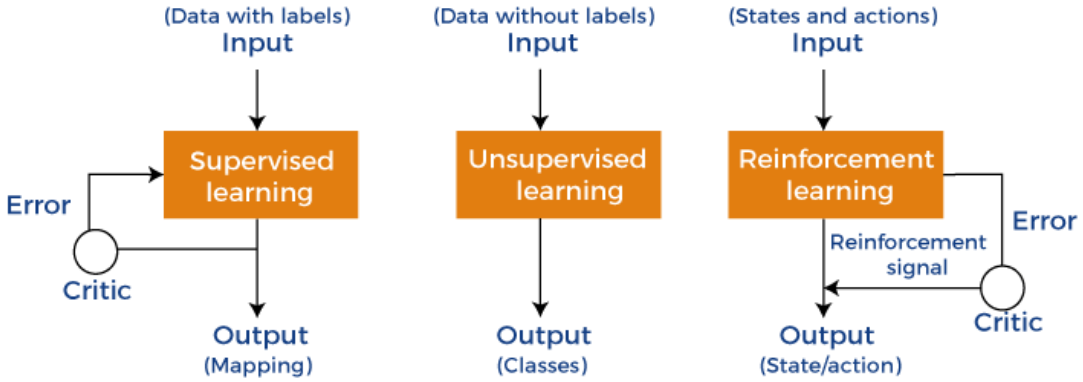

Figure 10: Classification of Machine Learning Models

Choosing the right machine learning algorithm depends on several factors, but not limited to data size, quality, and diversity, as well as what answers businesses wants to derive from that data. Additional considerations include accuracy, training time, parameters, data points and much more. Therefore, choosing the right algorithm is both a combination of business need, specification, experimentation, and time available. Considering all of the factors we have chosen Supervised Learning Algorithm. Supervised Learning models are used for regression and classification. As the type of problem that we are trying to solve belongs to the classification problem, we will further discuss on it.

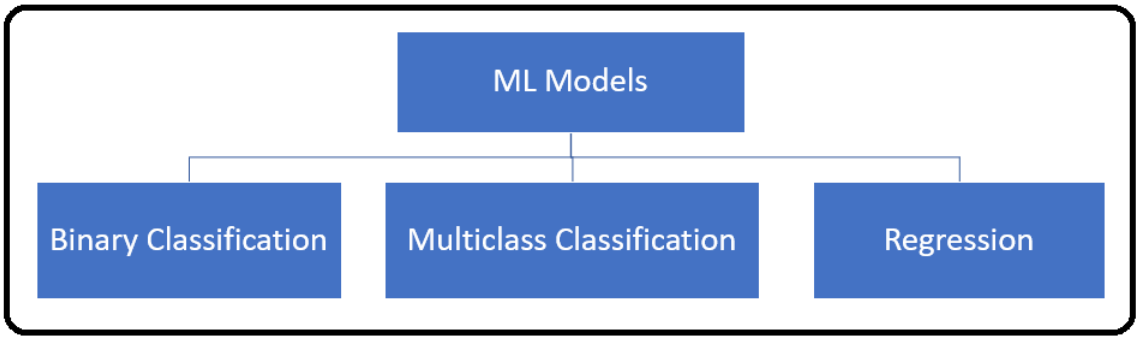

Figure 11: Classification of Supervised Learning

2.4. Classification Models

Classification models are the second type of Supervised Learning techniques, which are used to generate conclusions from observed values in the categorical form. For example, the classification model can identify if the email is spam or not; a buyer will purchase the product or not, etc. Classification algorithms are used to predict two classes and categorize the output into different groups. In classification, a classifier model is created that classifies the dataset into multiple categories, and each category is assigned a label.

2.4.1. Logistic Regression:

Logistic regression focuses on determining the likelihood of an event occurring based on the previous data presented. They are similar to linear regression but used to predict the categorical variables. It can anticipate the outcome in either Yes or No, 0 or 1, True or False, etc. However, rather of supplying the precise numbers, it delivers the probabilistic values between 0 & 1.

2.4.2. Naïve Bayes

The Naïve Bayes classifier is based on Bayes' theorem and classifies every value as independent of any other value. It allows us to predict a class/category, based on a given set of features, using probability. Each naïve Bayes classifier assumes that the value of a specific variable is independent of any other variable/feature. For example, if some fruit needs to be classified based on color, shape, and taste. So yellow, oval, and sweet will be recognized as mango. Here each feature is independent of other features.

2.4.3. Decision Trees

Decision Tree is a Supervised learning technique that can be used for both classification and Regression problems, but mostly it is preferred for solving Classification problems. It is a tree-structured classifier, where internal nodes represent the features of a dataset, branches represent the decision rules, and each leaf node represents the outcome. In a Decision tree, there are two nodes, which are the Decision Node and Leaf Node. Decision nodes are used to make any decision and have multiple branches, whereas Leaf nodes are the output of those decisions and do not contain any further branches. The decisions or the test are performed on the basis of features of the given dataset. It is a graphical representation for getting all the possible solutions to a problem/decision based on given conditions. A decision tree is a flow-chart-like tree structure that uses a branching method to illustrate every possible outcome of a decision. Each node within the tree represents a test on a specific variable – and each branch is the outcome of that test.

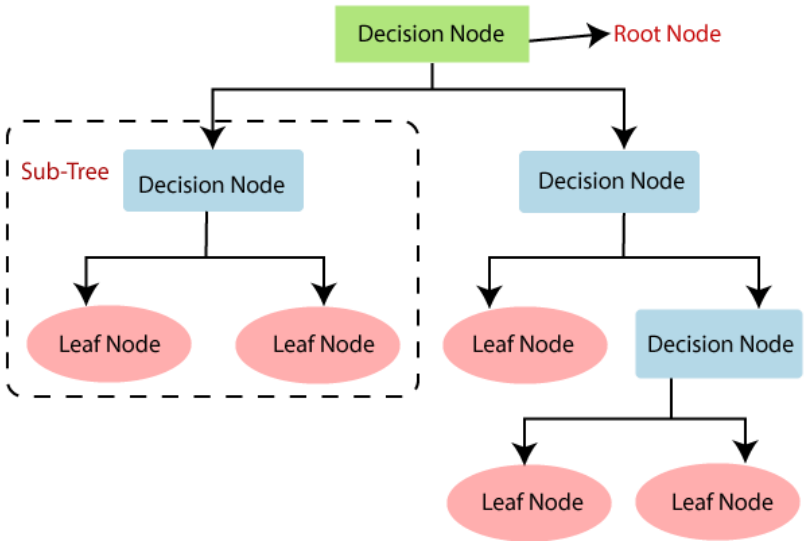

Figure 12: Decision Trees

2.4.4. KNN (K-Nearest-Neighbor)

The K-Nearest-Neighbor algorithm estimates how likely a data point is to be a member of one group or another. It essentially looks at the data points around a single data point to determine what group it is actually in. For example, if one point is on a grid and the algorithm is trying to determine what group that data point is in (Group A or Group B, for example) it would look at the data points near it to see what group the majority of the points are in.

Accuracy is undoubtedly a key criterion to take into account while selecting the best machine learning algorithms. We may proceed with either Design Tree or Naive Bayes while comparing the outcomes because of their high levels of accuracy. Therefore, choosing to consider the Accuracy, Decision Tree Model will be the best option.

2.5. Model Deployment on Web UI

Streamlit is an open-source app framework or Python library in Python language. It helps create web apps for data science and machine learning in a short time. User just have to import some Streamlit Libraries into python script(App script) to fetch the ML Model and to Deploy it with any Web base App. With the help of Streamlit, user can fetch the model through Python scripting to Simple Web UI. Where user has to provide some inputs like Force, Number of bolts, Strength, Factor of safety and Area. First Dump the ML Model into ".pickle" file (Import pickle Package/Library as well) and then use it into App script to create a Web App.

Now, simply run this python script file with Streamlit command ➔ **streamlit run <.py file>**. As soon as you run the script as shown above, a local Streamlit server will spin up and app will open in a new tab in default web browser. User can also deploy this model within the Streamlit itself, as here we have deployed this model on GitHub. So ultimately user will be able to share and integrate this model with other projects within the team or company.

Chapter 3: Results and Discussion

Objectives Discussed

- ***AI/ML, adopt efficient ways to work on complex assemblies and data, Data management, New or efficient Technologies***
- ***Cost and time effective Design, optimizing existing business services, Increasing revenue***

3.1. Data Generation

Data was generated for the 25 classes of standard Metric threads. One thousand datasets for each class were generated using the design procedure for the foundation bolts. The input features were Force applied in the application, number of bolts, factor of safety, ultimate tensile strength of the material and tensile stress area of metric thread.

	Force	No_Bolts	Strength	FOS	Area
14149	1124700	5	800	1.10	343.658333
8946	59400	7	400	1.10	25.928571
22378	7801200	6	400	1.10	3972.833333
12162	435000	6	800	1.25	125.868056
4879	10900	6	400	1.10	5.550926

Figure 13: Input features for Machine Learning Model

	Force	No_Bolts	Strength	FOS	Area	Bolt_Diameter	Pitch	Standard_Area	Thread_Size
0	4050	6	800	1.10	1.031250	1.6	0.35	1.27	M1
1	1700	8	400	1.25	0.737847	1.6	0.35	1.27	M1
2	1650	5	400	1.25	1.145833	1.6	0.35	1.27	M1
3	200	4	400	1.25	0.173611	1.6	0.35	1.27	M1
4	800	8	400	1.10	0.305556	1.6	0.35	1.27	M1

Figure 14: Input and output features for Machine Learning Model

3.2. Machine Learning Model Accuracies

Machine Learning Model	Training Accuracy	Testing Accuracy
Logistic Regression	4 %	4 %
Naïve Bayes	47 %	48 %
Decision Trees	100 %	100 %
KNN (K-Nearest-Neighbor)	55 %	34 %

Among the different machine learning algorithms decision tree was selected as it has more testing and training accuracy. Decision Tree model was used for further prediction of standard bolts.

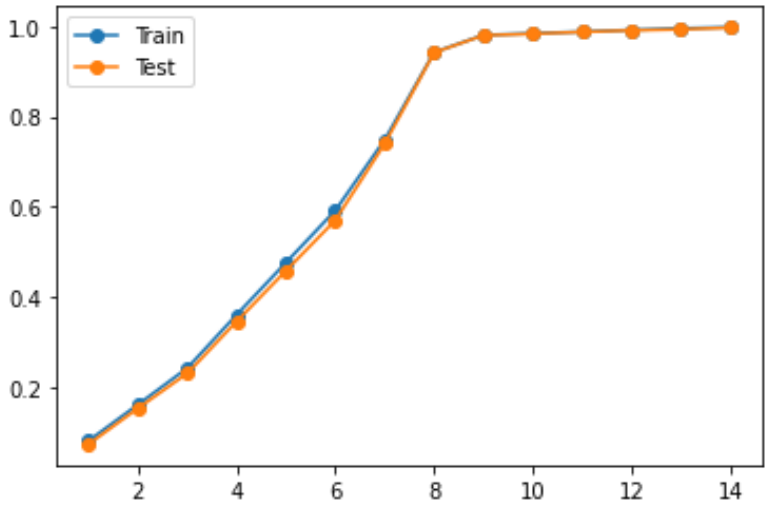

Figure 15: Training Vs Test Accuracy

3.3. Model Deployment

If we specify the force applied in an application the Machine learning model will recommend the required size of the bolt and the Metric Thread. There is total 25 classes of Standard Metric threads which are used all over the world. We can prepare the models for them beforehand and can store them in the default library of the Inventor. We can directly fetch the recommended bolt from the Standard bolts Catalog for a given application. These will save the amount of time and efforts to model a product along with the all the design procedure. As we have used Multiclass classification ML Model, it will automatically classify the data and gives the results by comparing both calculated and standard areas. Ultimately it will pick the specific size of Standard bolt from that we have created in fusion.

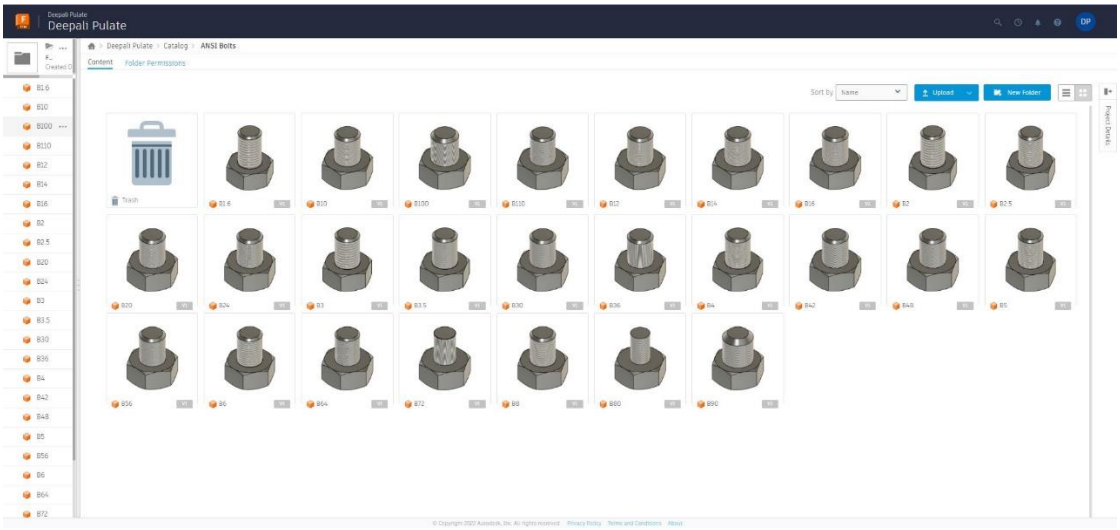

Figure 16: Standard Size Bolt Catalog

The model deployment on the Web UI has been done through the Streamlit. Currently we have accessed the model with Streamlit i.e., directly fetched the model through Web UI with python Script. Streamlit helps to fetch the model through Python script and further deploys it to Simple Web UI. Where user has to provide some inputs like Force, Number of bolts, Strength, Factor of safety and Area. As you can see in the image Decision tree model has given the accurate result with Bolt size M36 (Also confirm with the dataset that we have already created).

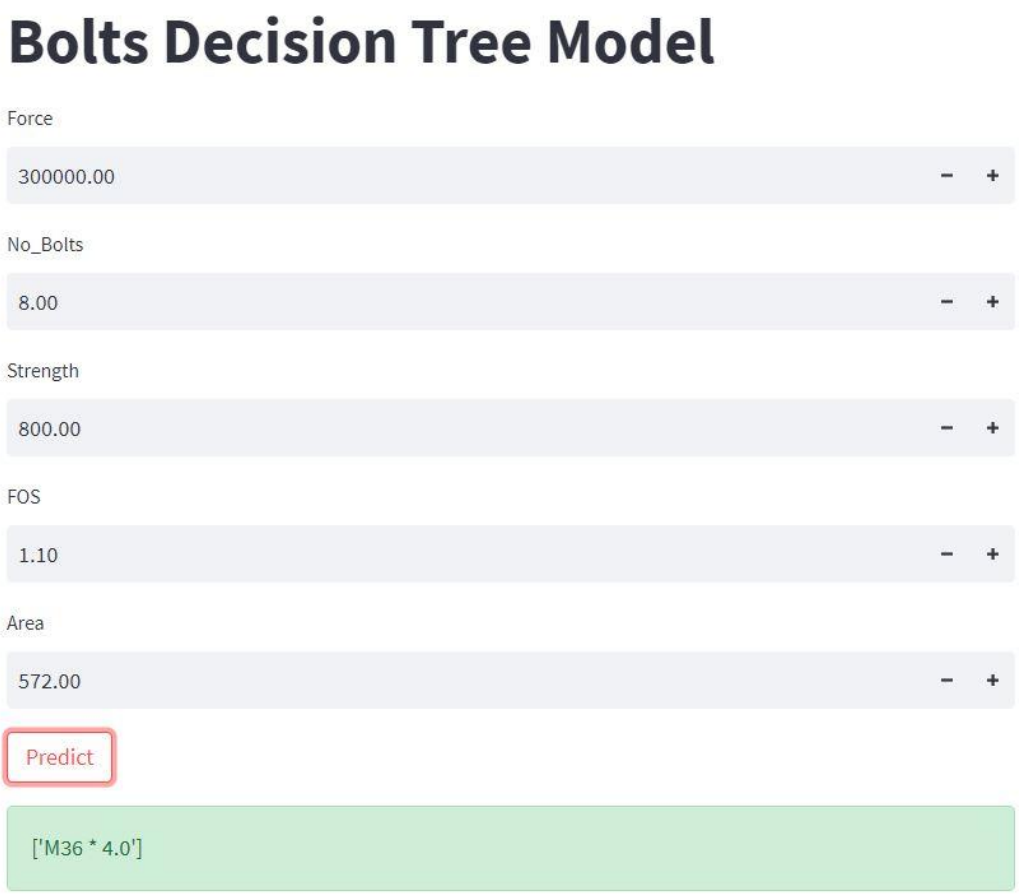

Figure 17: Deployment of Machine Learning Model to a Web UI

Uptilt now we have considered the Bolts example for detail illustration, but in market or in real value world scenario where complex problems comes into pictures, where making a decision is a big headache or rather, a time consuming and costly task. To automate this process one can easily implement above type of ML model. Increasing customer satisfaction, offering differentiated digital services, Automating business operations.

Conclusion

The role of artificial intelligence (AI) tools and techniques in business and the global economy is a hot topic. This is not surprising given that AI might usher in radical—arguably unprecedented—changes in the way people live and work. The AI revolution is not in its infancy, but most of its economic impact is yet to come.

It helps companies to automate tedious tasks to save time and efforts. Also, it gives customer satisfaction which is more important for the business growth and increases the revenue. The companies who have large amount of data and complex assemblies they can easily mold to these techniques to reduce the tedious and complex tasks of designing by implementing/Integrating ML model with their current frameworks.

Basically, AI is need of future. To cope up with this competitive world, industries must upgrade themselves or we already know the consequences of it. Artificial intelligence has large potential to contribute to global economic activity. But widening gaps among countries, companies, and workers will need to be managed to maximize the benefits. Someone has already said, There are always “New Thinking , New Possibilities”.

Hopefully, this Handout helps you to speed up and enhance your own digital transformation journey! I would love to hear your feedback or answer or any questions you might have. If you enjoyed this, I would appreciate if you can press ‘Recommend’ on the Class page and I will make sure to answer questions if you leave them in the comment box. I’ve provided several links below which you might find useful in addition to this class.

That’s it from our side, until the next year’s Autodesk University!

Chapter 4: Future Scope

Objectives Discussed

- ***Increasing customer satisfaction, offering differentiated digital services, Automating business operations***

With the help of Fusion 360 APIs, we can directly integrate ML Model through Script or Add-In. Eventually model will get leverage of Already stored Database in PLM to get specific results. In future one can also calculate on the fly (i.e., while designing an assembly) required Size of Standard Bolt, with the help of calculated real time forces applied and it will automatically pick up the Standard size of bolts from the Catalog too.

Fusion gives a platform to user for customization through APIs. User can ether fetch it through Add-In or Script. Giving an example for Bolts, created Catalog of ANSI Standard bolts in Fusion 360 with the help of Script. If we consider the same with large manufacturing companies like Seats, they already have huge amount of dataset stored in their database and can similarly fetch through integrated PLM Software or CAD Catalog just by giving specific inputs through ML model.

For now, we haven't integrated Model with the Fusion 360 or PLM software due to some restrictions and time constrain, but we can use it by fetching Fusion 360 APIs. It would be more easy and fast process if we directly integrate it with web applications. Ultimately it increases customer satisfaction as well.

References

1) Shigley's Mechanical Engineering Design_TextBook - by Richard Budynas (Author), Keith Nisbett (Author)
2) References from McKinsey & Company magazines
3) https://streamlit.io/
4) https://intellipaat.com/blog/tutorial/python-tutorial/scikit-learn-tutorial/