AUTODESK. UNIVERSITY

Combining Forge and Machine Learning to Automate Time-Consuming Tasks.

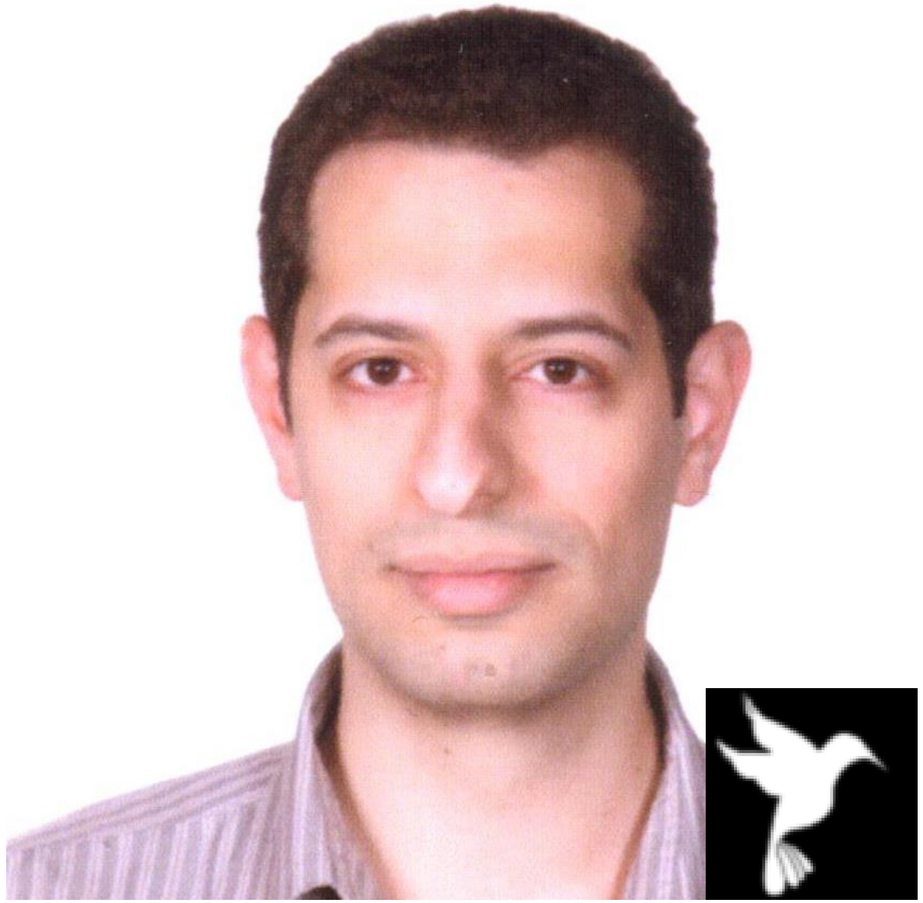
Rana Zeitouny

Project Manager at EMDC Group| @ranazeitouny

About the speaker

Rana Zeitouny

Rana entered the engineering consultancy industry in 2002, after obtaining her bachelor's degree in Electrical Engineering from the Lebanese American University in Lebanon. Since then, she deeply grasped the AutoCAD software and in 2005, she standardized the AutoCAD implementation including layers, blocks, commands, shortcuts, etc. and trained the Electrical department. From 2008 till 2016, she gave university courses about Electrical Design including training sessions on AutoCAD software. Today, after taking a REVIT training in 2015, she is using both AutoCAD and REVIT software in her daily consultancy works. She currently works as a Project Manager at EMDC Group, a rapidly evolving electro-mechanical design and consultancy firm with large scale projects, distributed in the Arab & Gulf Area, Africa and Latin America.



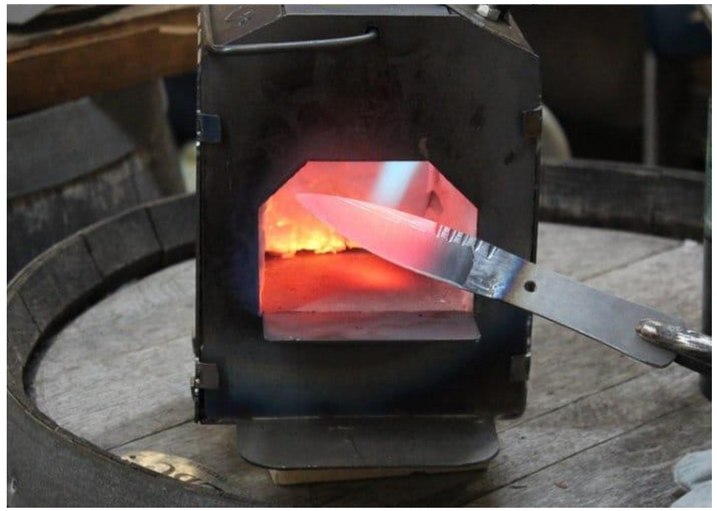
About the co-speaker

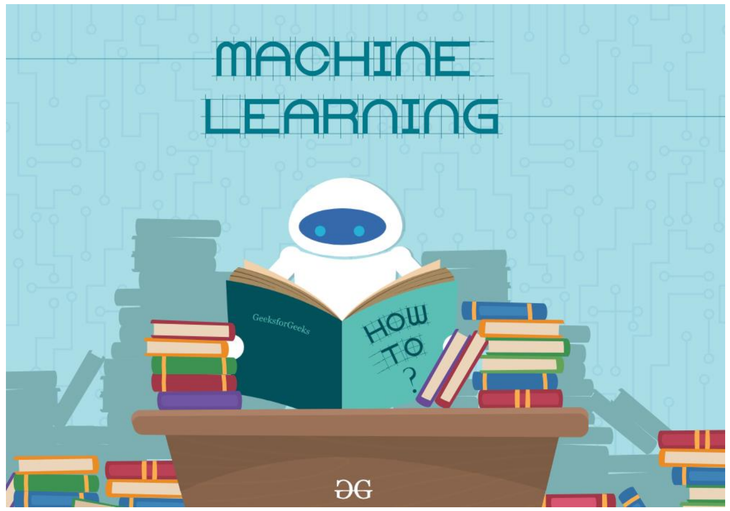
Majd Makhlouf

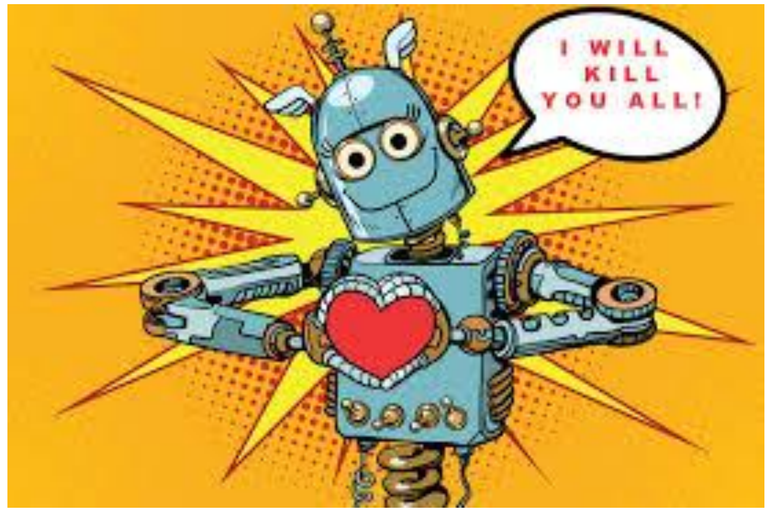
Majd is a Mechanical Engineer and Design Technologist, with a Master of Science in Mechanical Engineering. He's an Autodesk Revit Certified Professional and a member of the Autodesk Developer Network. In January 2020, he founded Building Information Researchers and Developers OÜ, a software development company based in Estonia and providing services for the AEC sector worldwide. He specializes in BIM Management, Autodesk Revit and AutoCAD Add-in development, both public and custom developed, Forge web and cloud based apps, Dynamo Zero Touch Node Packs, and mobile VR/AR applications.

Introduction: Defining the Buzzwords

Combining **Forge** and **Machine Learning** to Automate Time Consuming Tasks?







Automating Time Consuming Tasks

ESSENTIAL TO MEET DEADLINES

LEAVES MORE TIME FOR DECISION MAKING

TREMENDOUSLY BRINGS DOWN PROJECT DURATION AND COST

Limitations

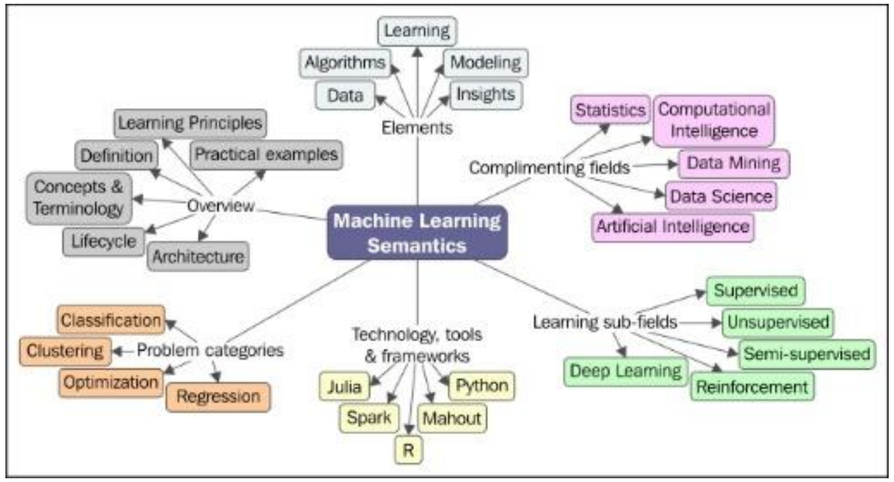
DESKTOP RESOURCES

PROCESSES THAT STILL REQUIRE MANUAL INPUT

API LIMITATIONS

ALTERNATIVE SOLUTIONS

AUTODESK FORGE®



Class Objectives

DESCRIBE

the concept and advantages of cloud computing and the Autodesk Forge platform

EXPLORE

machine learning as an automation method that analytically builds data models and identifies data correlations

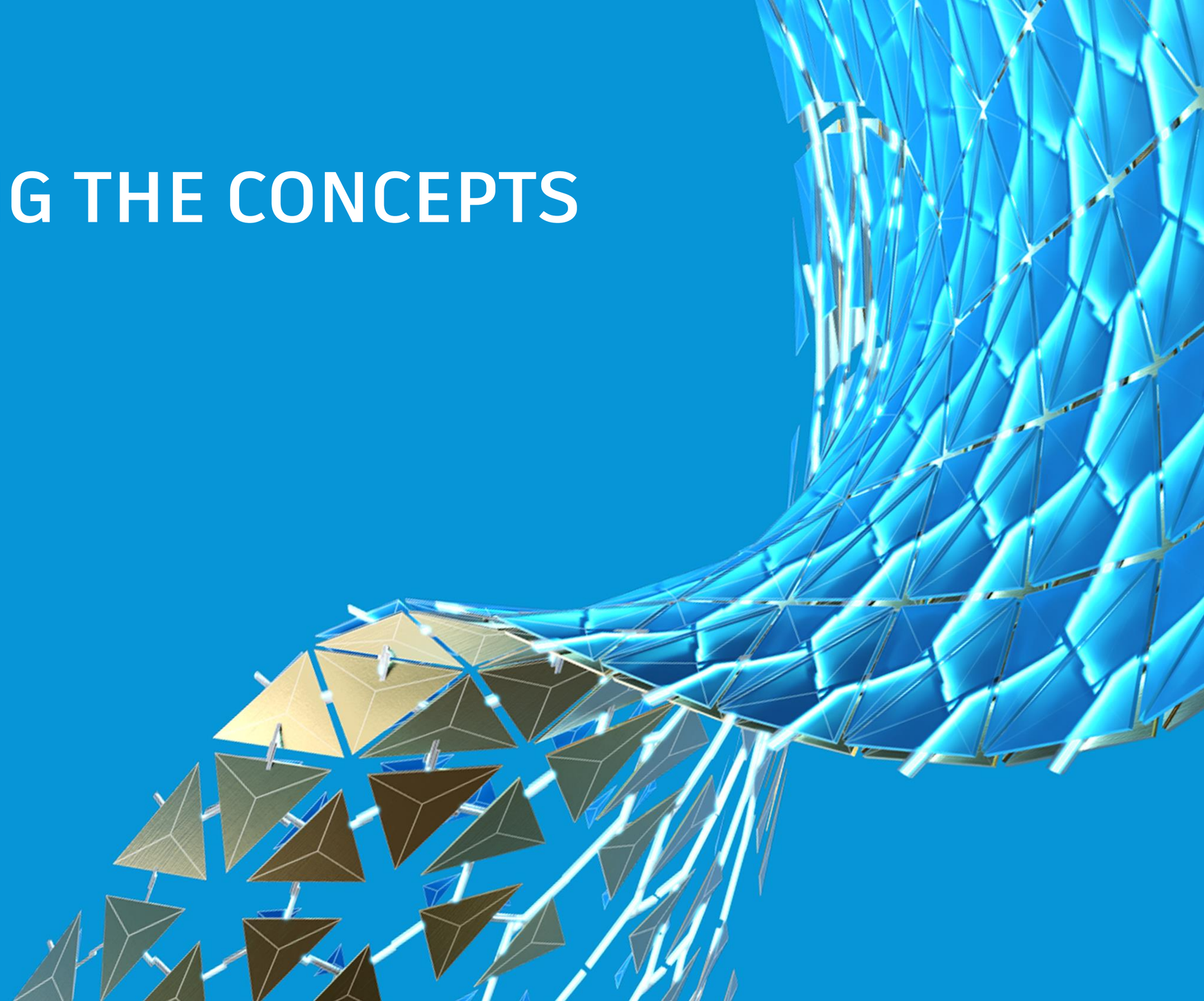
IDENTIFY

repetitive tasks that can nowadays be automated through machine learning and cloud computing

ESTIMATE

the benefits of integrating revolutionary technologies into a firm's daily workflow

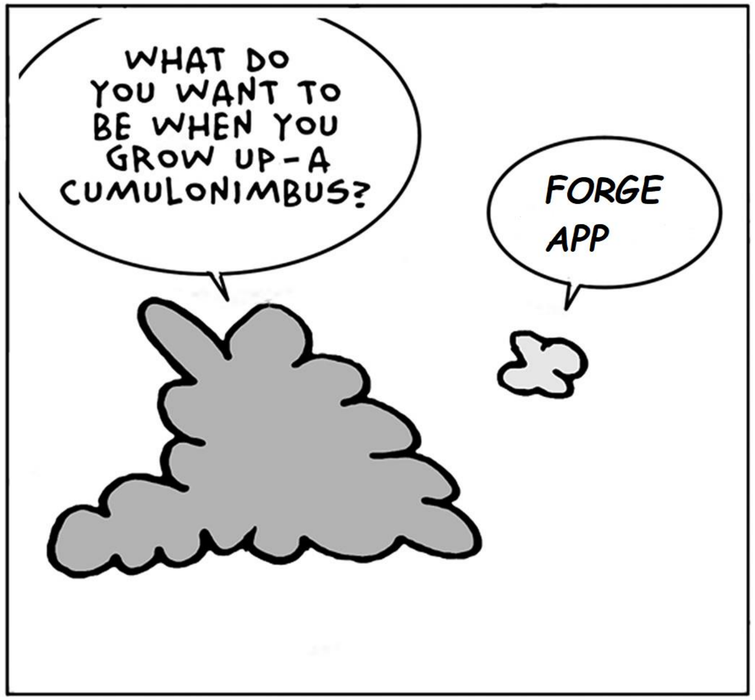
INTRODUCING THE CONCEPTS



What is Autodesk Forge?

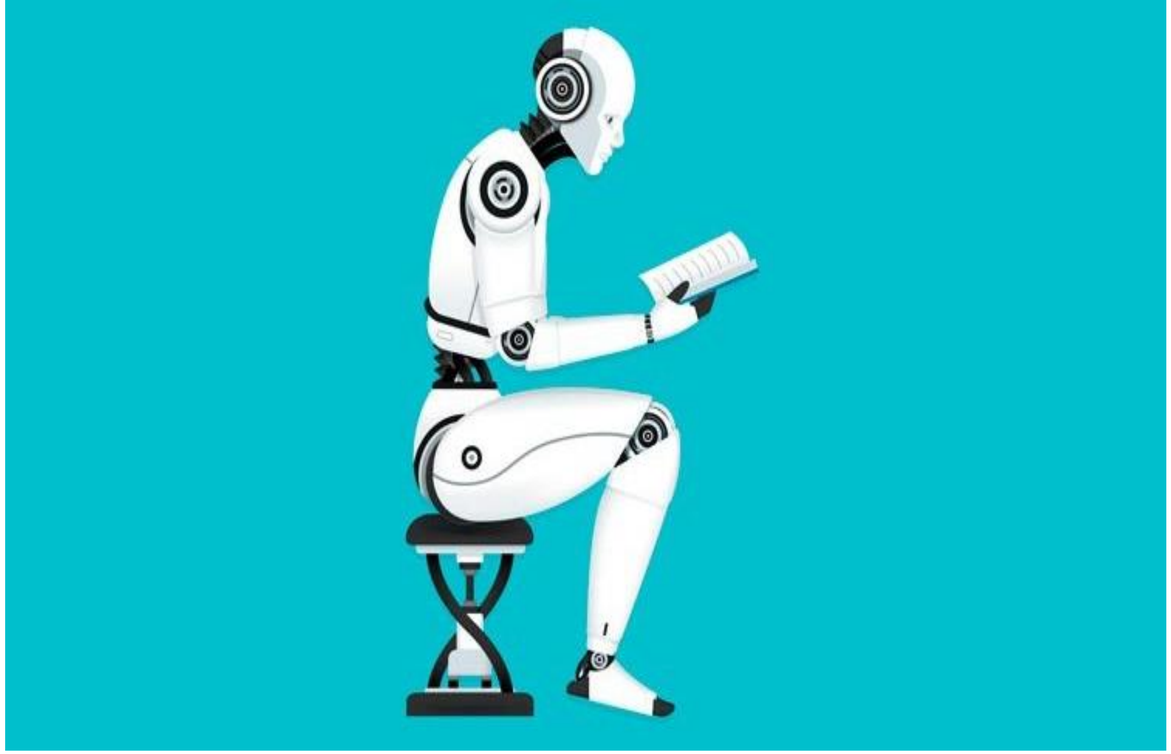
A cloud-based developer platform from Autodesk. Involves several APIs:

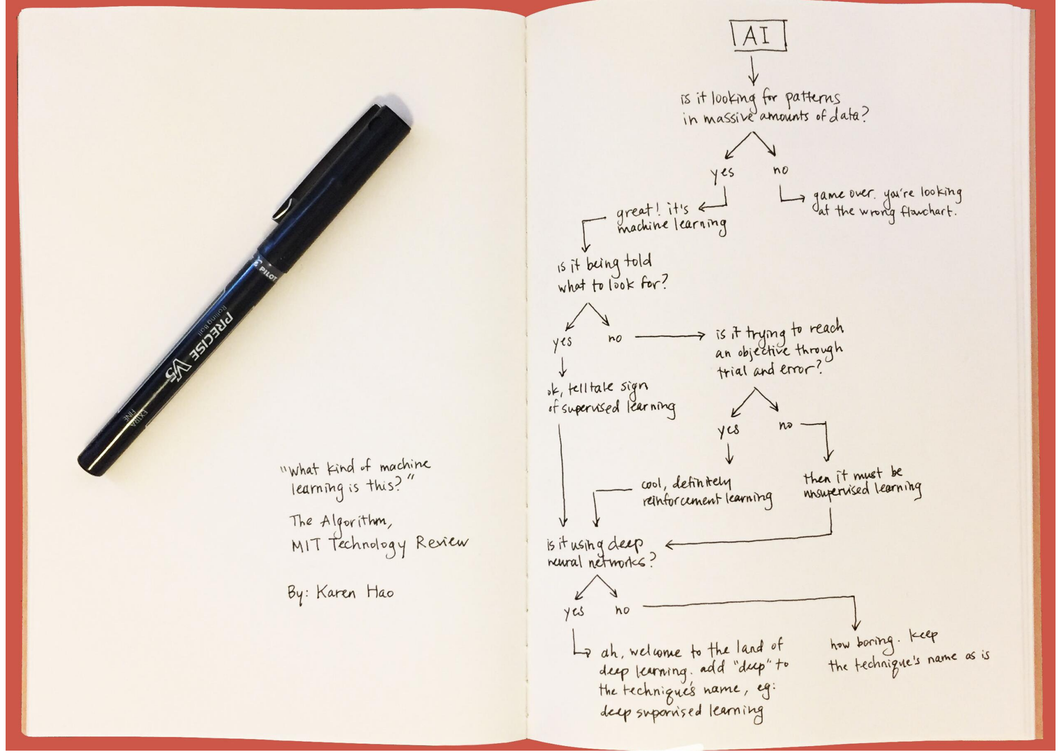
- **BIM 360 API.**
  - Enables the automation of BIM 360 related operations.
    - Ex: setting user permission, creating new projects…
- **Data Management API**
  - Enables the automation of could hosting transfer operations.
    - Ex: BIM 360 Docs downloads, uploads…
- **Reality Capture API**
  - Manipulates 3D capture models.
    - Ex: Point Clouds, High Resolution Images….
- **Design Automation API (Main Focus of this Class)**
  - Simply put: Runs Autodesk Software instances and executes scripts and add-ins in the cloud.
    - Supported Platforms: AutoCAD, Revit, 3DS Max, Inventor.



Why use the Design Automation API?

- Provides additional virtual workstation in case everyone available in place is in use.
- Offers an increased performance compared with desktop solution.
- Lower execution times
- Is accessible from any Desktop or mobile platform or web browser.





WHAT MACHINE LEARNING ISN'T:

- A synonym for Artificial Intelligence
- Machines gaining self awareness and starting to read and speak
- Computers gradually gaining control over the world

WHAT IT REALLY IS:

- A subdivision of Artificial Intelligence
- A combination of the statistics and probability you hated back in college
- Automated statistical algorithms that process input data and finds data relations
- Automated probabilistic processes that predict new values based on previously processed Data.

ALL MODELS ARE WRONG, BUT SOME ARE USEFUL

GEORGE E.P. BOX

When is Machine Learning Needed?

SHORTAGE OF INFORMATION

When dealing with non parametric objects.

Ex: 2D CAD drawings; Fake BIM Models; Point Clouds; Raster images…

API LIMITATIONS

When a functionality is not exposed by the API, or Automating a process cannot be achieved through conventional statements (Ex: If statements, For loops, While loops…)

2 OPTIONS

MANUAL INPUT

Dedicate a team of employees to do the required work manually.

TRAIN A MACHINE LEARNING ALGORITHM

Gather data from previous models, find a data relationship (statistical part), and use it to predict the missing parameter values and automate your process (probabilistic part).

Sample Revit Automation – Machine Learning not Required

- Automated P-Trap Connection
- Automated Hanger Placement
- Attached Hangers

Can be achieved through the Revit API when a model is correctly modeled, and all necessary parameters are available.

The above 3 samples illustrate explicit automations and do not use any aspect of Machine Learning.

These samples can be found at www.emdc-forge.com\samples.

Can’t Be (Conventionally) Automated

- Scanned PDF Data Extraction
- Documentation of Exploded CAD drawings
- Raster Image Detail Conversion
- Point Cloud to BIM model conversion

- Manual Input Required
- Out of Scope Work
- Overtime for Employees
- Overpayment

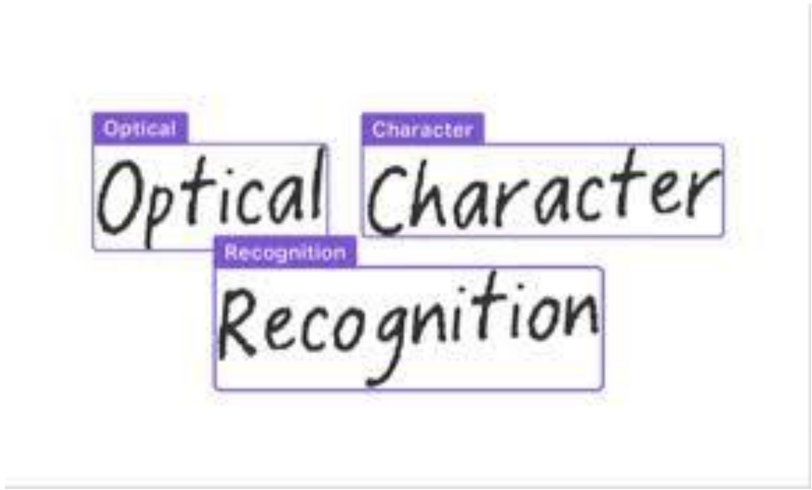
Can’t Be (Conventionally) Automated - Solution

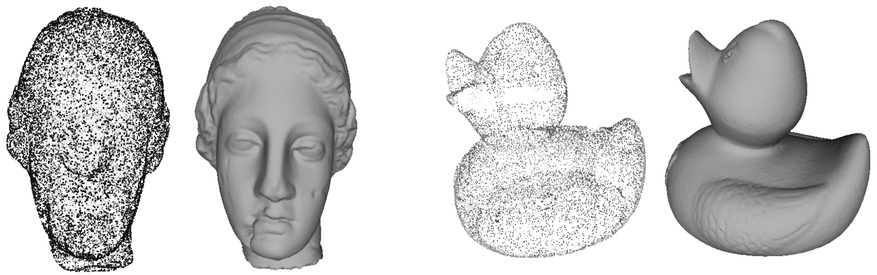
- Scanned PDF Data Extraction
- Documentation of Exploded CAD drawings
- Raster Image Detail Conversion
- Point Cloud to BIM model conversion

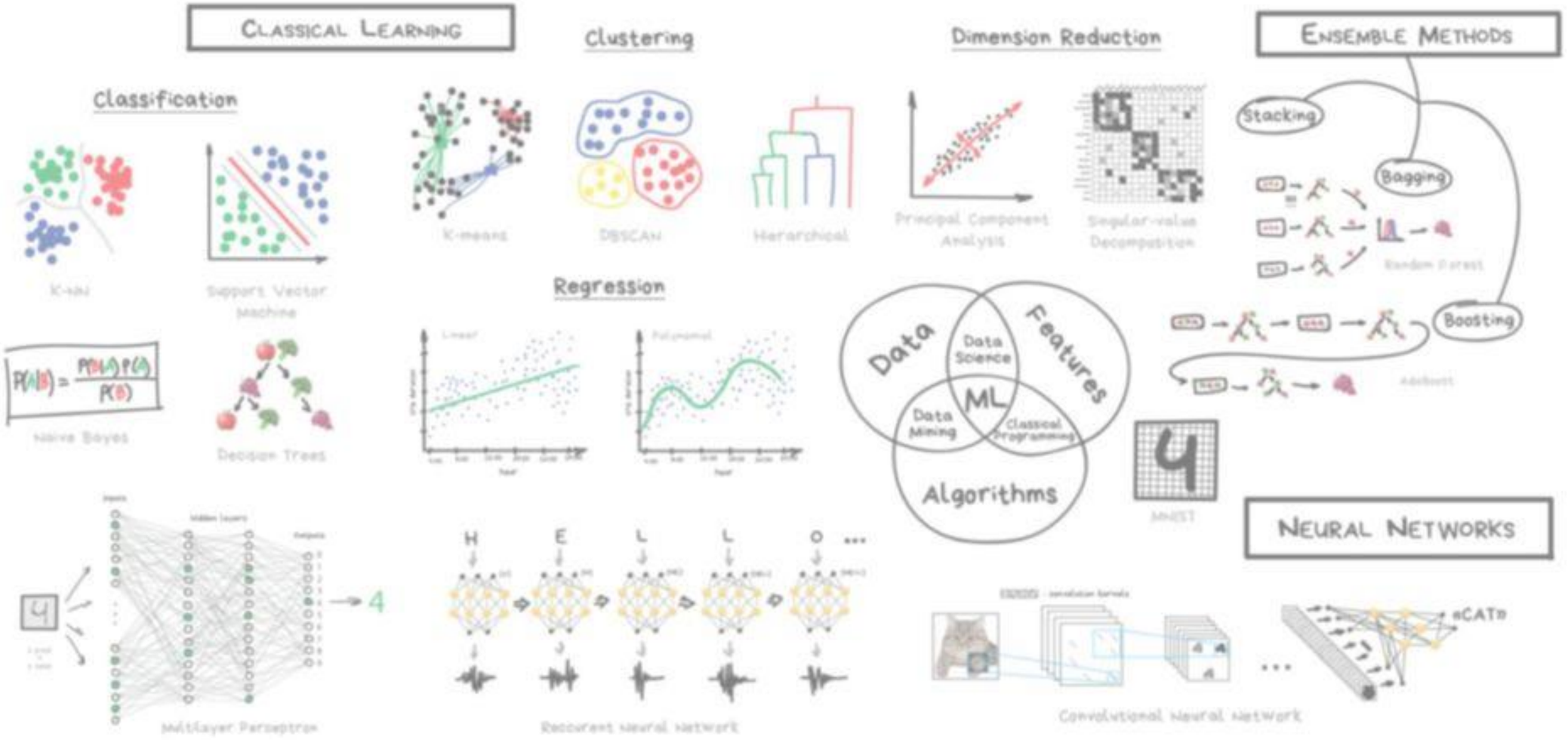
- Solution 1: Train Any Operator To Do That Task
- Solution 2: Train an Algorithm using Machine Learning!

Can’t Be (Conventionally) Automated – Solutions

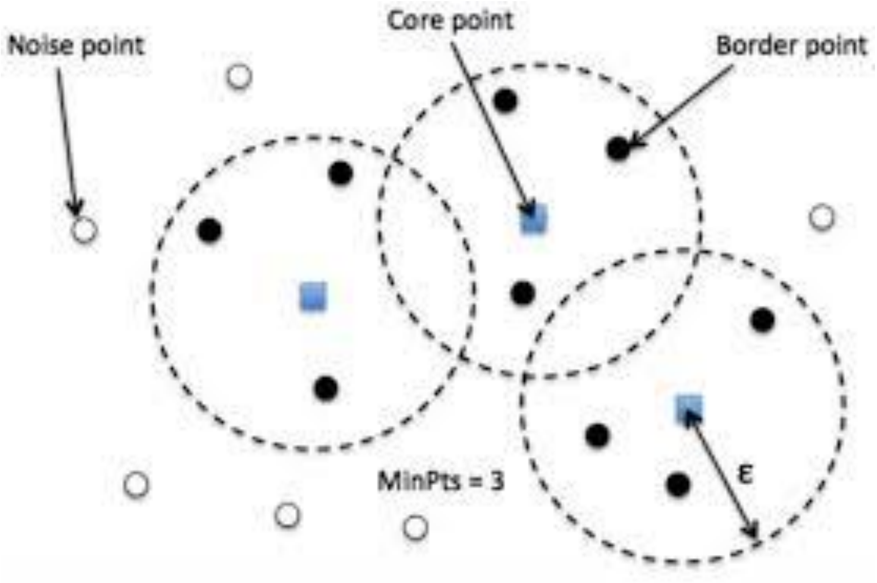
- Scanned PDF Data Extraction -> **Automated OCR + Machine Learning algorithm to recognize typical schematics.**
- Documentation of Exploded CAD drawings-> **Use Machine Learning to find sheet information and document it, based on previous cases.**
- Raster Image Detail Conversion-> **Use of Vectorization software which uses Machine Learning to detect lines, circles…**
- Point Cloud to BIM model conversion -> **Use of Machine Learning to automatically detect elements.**

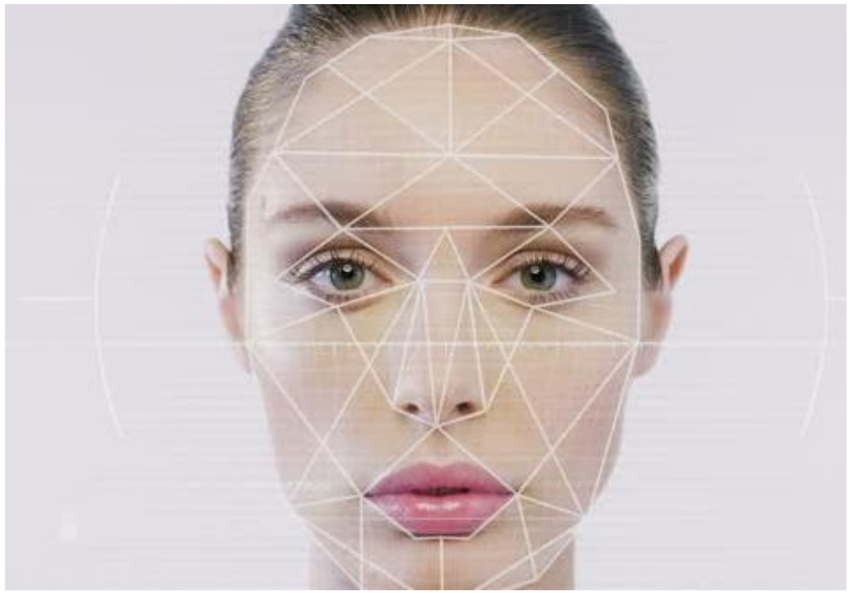






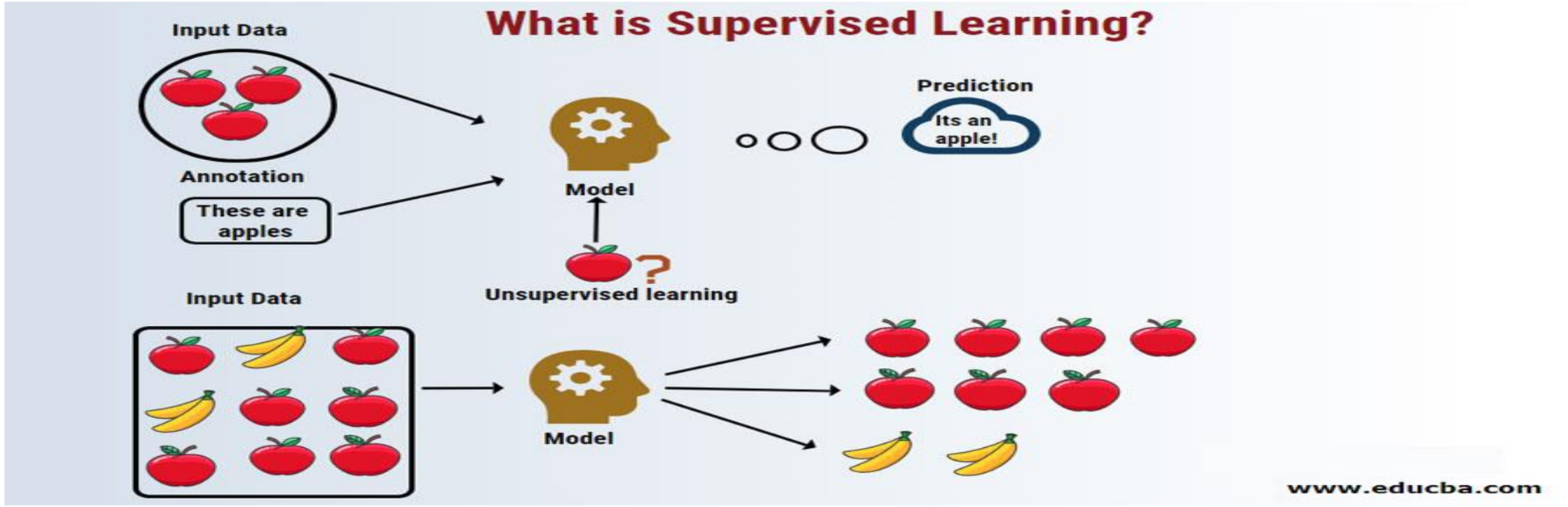
MACHINE LEARNING SUBFIELDS WE USED TO AUTOMATE REAL CASE SCENARIOS AT EMDC GROUP





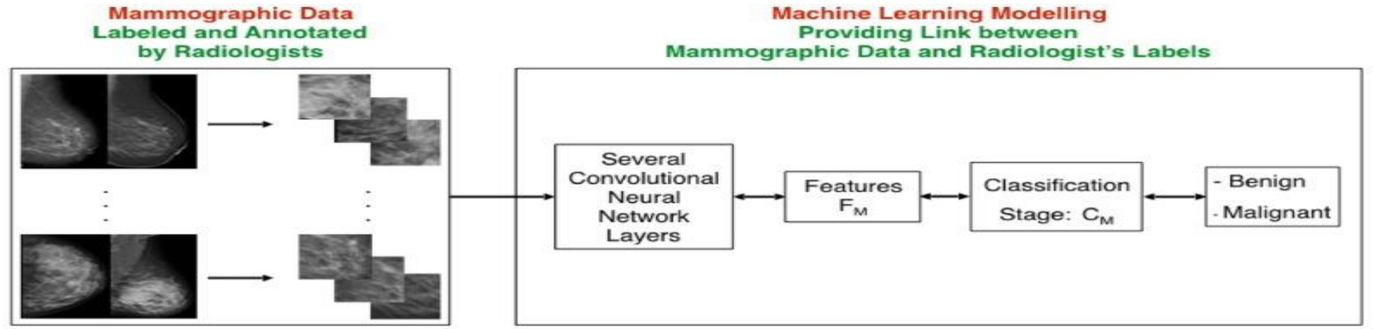
Clustering

- GROUPING BASED ON SIMILARITY
- UNSUPERVISED
- FINDS PATTERNS BASED ON DATA DENSITY (EX: DBSCAN), OR MEAN VALUES (K-MEANS)
- EX: FACIAL RECOGNITION

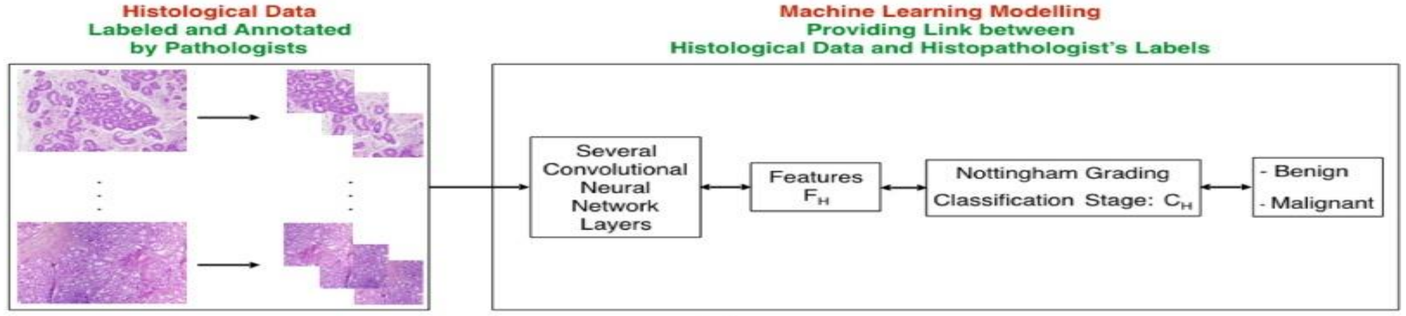


Supervised Learning

- FEED LABELED DATA IN
- FIND DATA RELATIONS
- PREDICT RESULTS FOR UNLABELED DATA
- EX: CANCER PREDICTION ALGORITHMS



(a) $Model_M$



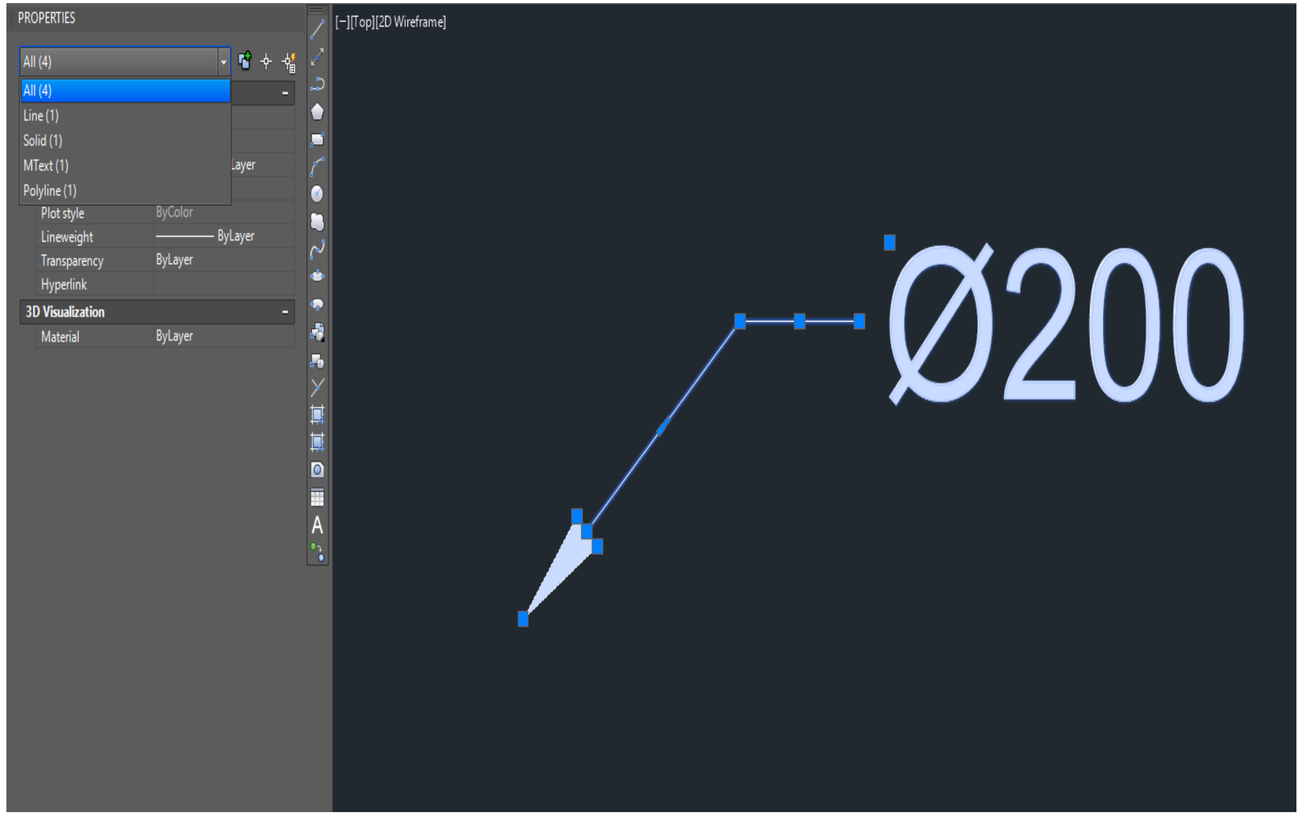
(b) $Model_H$

REAL CASE SCENARIO 1: USING CLUSTERING TO AUTOMATE MULTILEADER GROUPING

Defining the Problem

A client wants to produce detailed AutoCAD drawings based on a BIM model.

- Exporting AutoCAD drawings from Revit saves 50% of the work.
  - **Problem:** Tags are exported into exploded multileaders
    - Multileaders **required** by the client

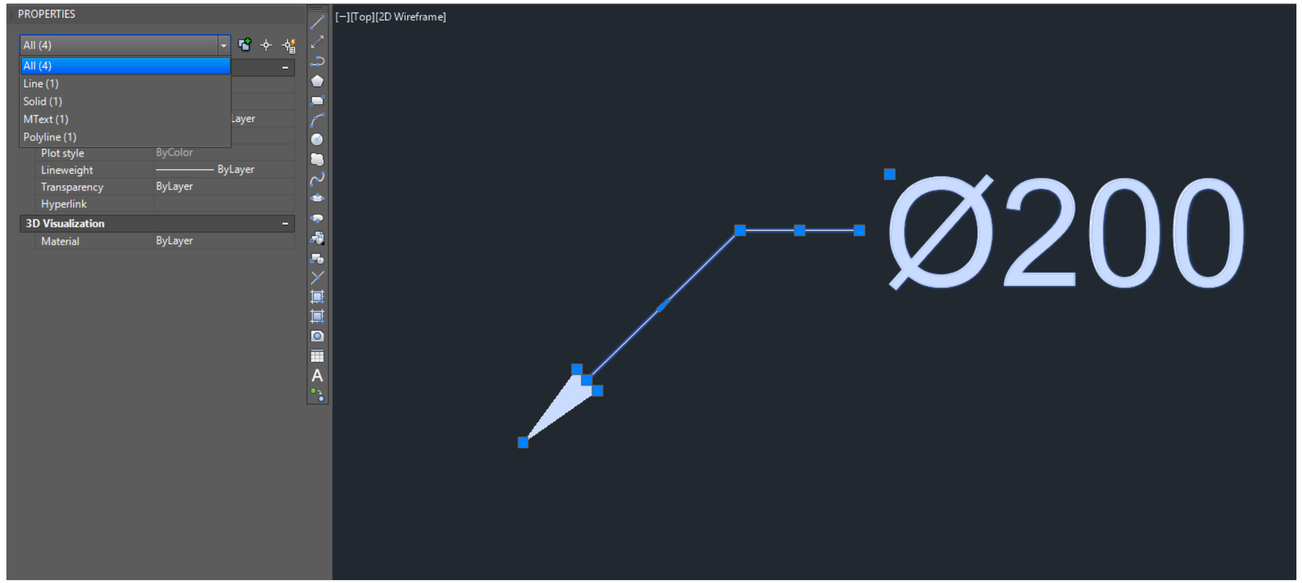


Classical Solution

AutoLISP Routine to Group Text Elements/Exploded Leaders into Multileaders

```
(defun C:myfunc ( / I ITEM SS)
  (setq i 0)
  (princ "Select Text Objects")
  (setq ss (ssget '((0 . "TEXT"))))
  (repeat (sslength ss)
    (setq item (ssname ss i))
    (princ (cdr (assoc 7 (entget item))))
  )
)
```

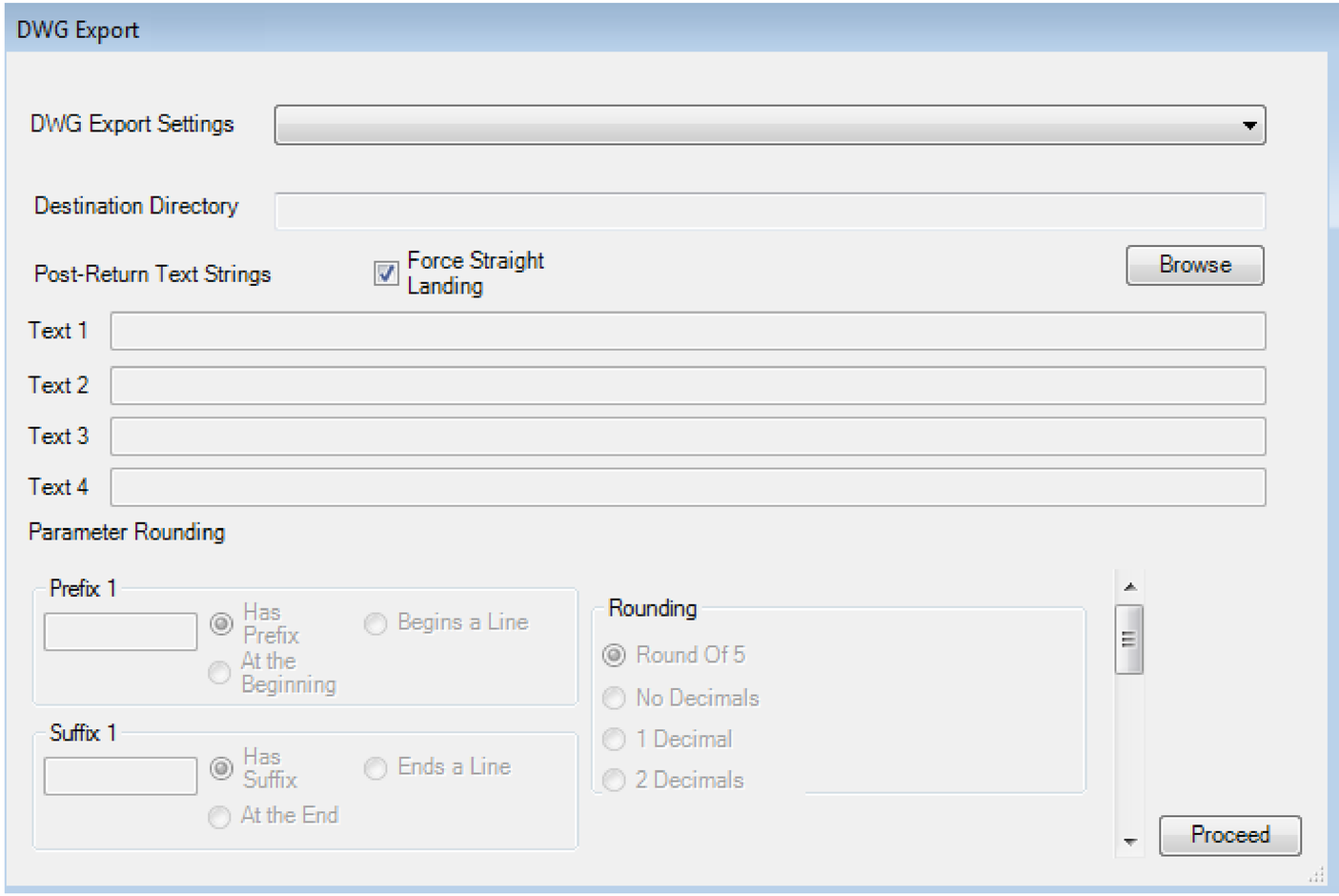
- **User selects the elements to be grouped, one group at a time.**
  - **Problem:** Still requires manual input.
    - **Solution: DBSCAN Clustering** algorithm: groups multileader elements into multileaders based on their distribution density around each text, sorting them out without needing user input.

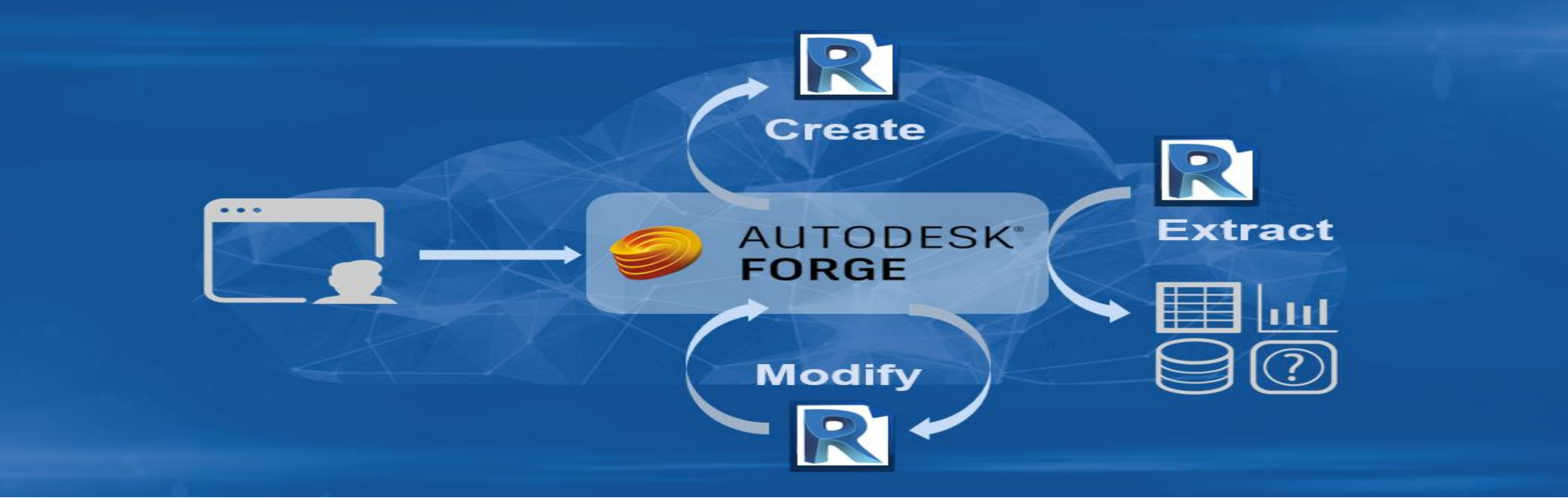


Implementing Solution

Revit API based Add-In to execute DBSCAN Algorithm over exported AutoCAD drawings

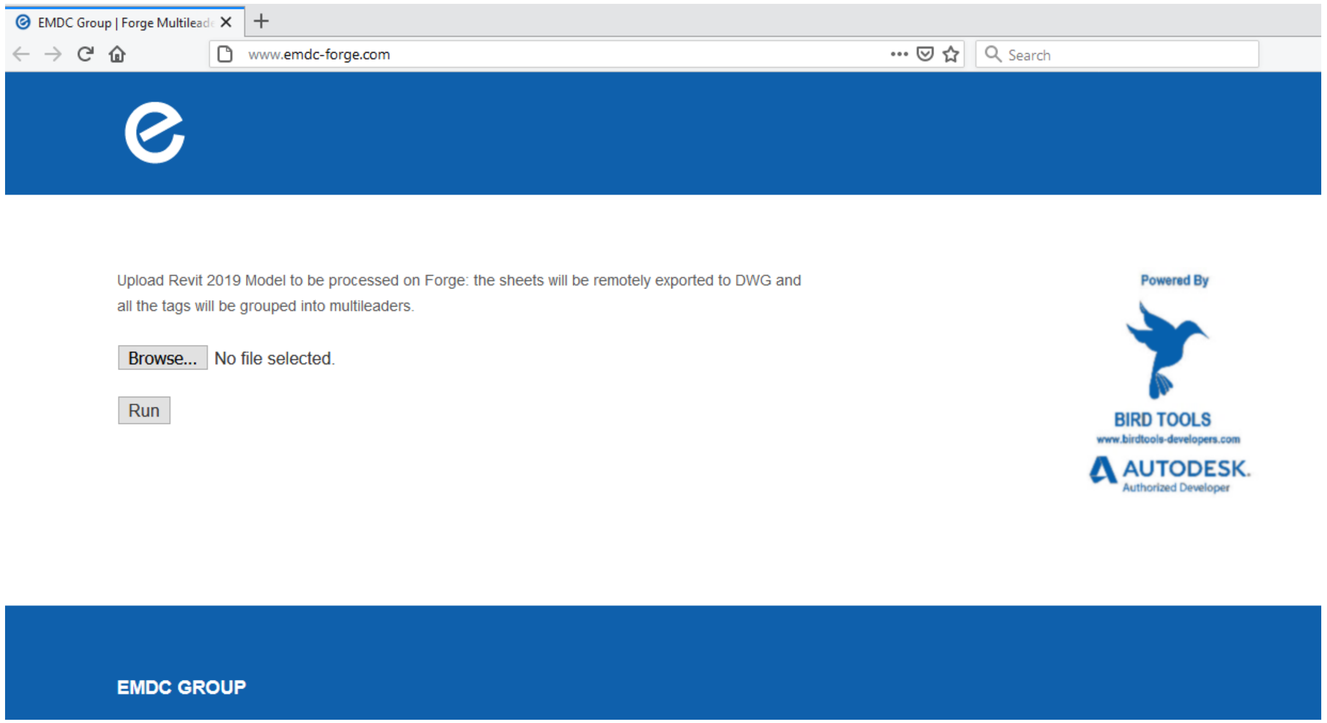
- **Uses ACAD Interoperability to process drawings as soon as they are exported.**
  - Saves drawing opening time and eliminates manual input.
    - **Problem**: Resource Heavy Algorithm, Implying Longer Execution Time and Requiring Dedicated Workstations.

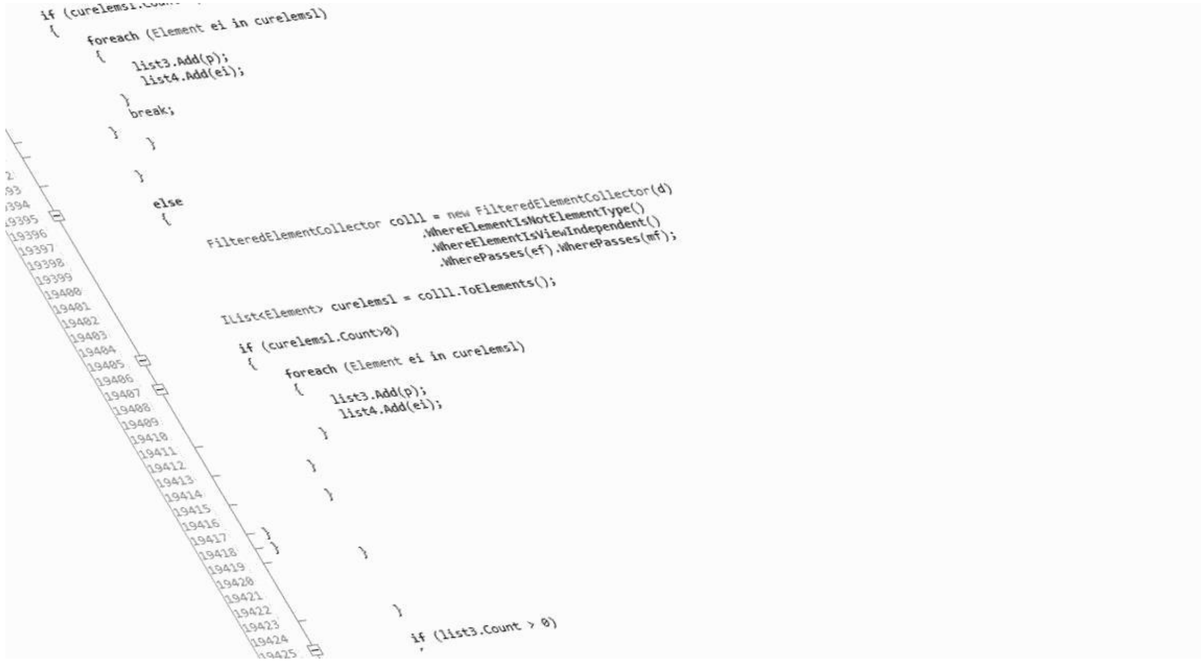




SOLUTION: FORGE DESIGN AUTOMATION FOR REVIT

- Desktop Add-In converted into a Forge Add-In.
- Lower Execution Time
- Less User Interaction
- Desktop Workstations Saved for other Tasks.
- Web page accessible through any device at: **www.emdc-forge.com**





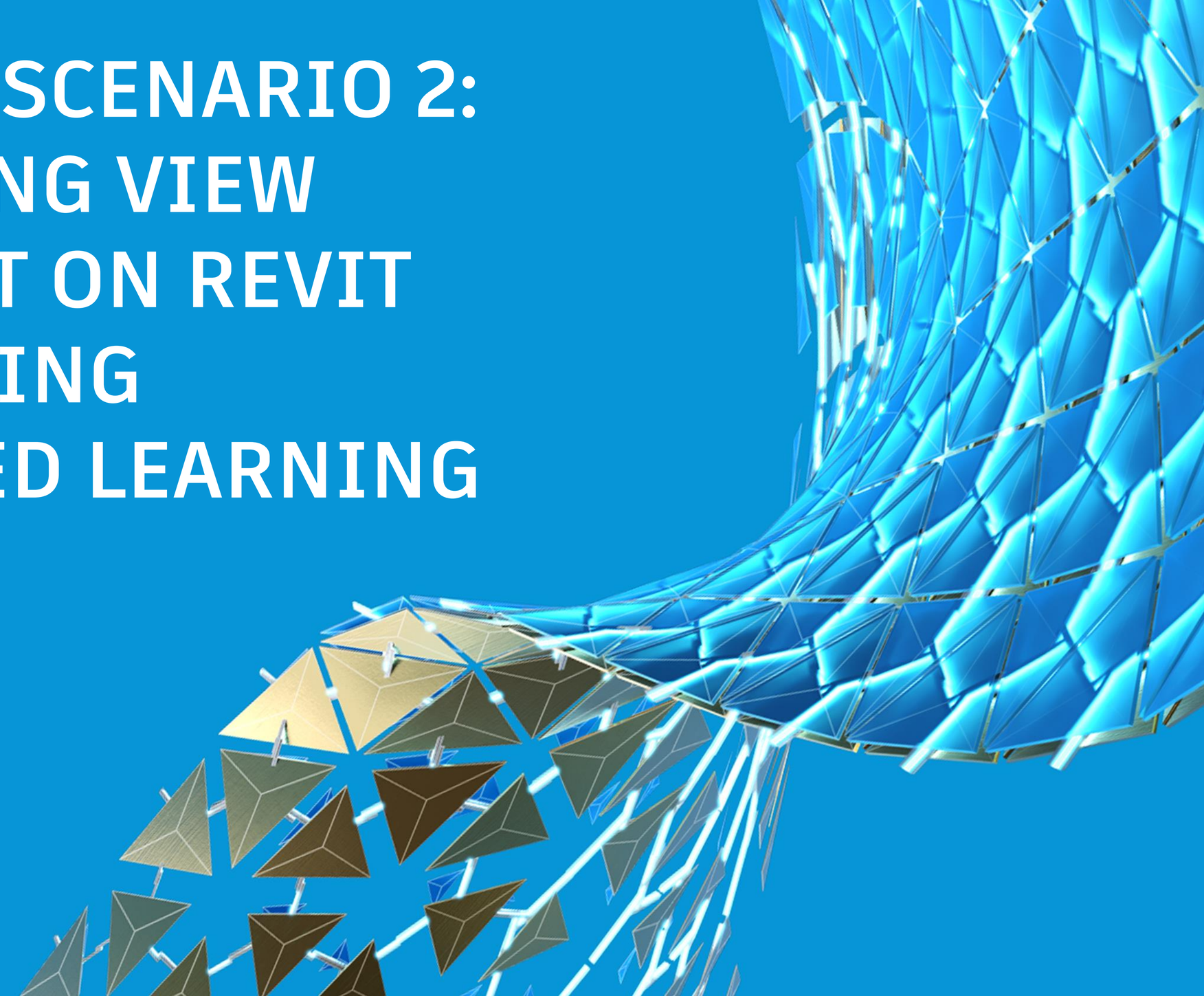
HTML INTERFACE

- HTML Requests posted to the application
- Post commands to upload models, run workitems, download resulting files…
- Can be posted using any interface/programming language (cURL, Javascript, ASP.NET, Ruby, Python…)
- Javascript used: can be accessed through any desktop or mobile web browser

REVIT API-BASED BUNDLE

- The actual add-in running remotely in the remote Revit session
- Executes based on the posted HTML requests
- Uploaded as Bundle to Forge
- .NET compiled Class Assembly.
- C#, F#, VB.NET,C++… Any .NET programming language can be used
- No interfaces involved. All interfaces covered through the HTML part of the app

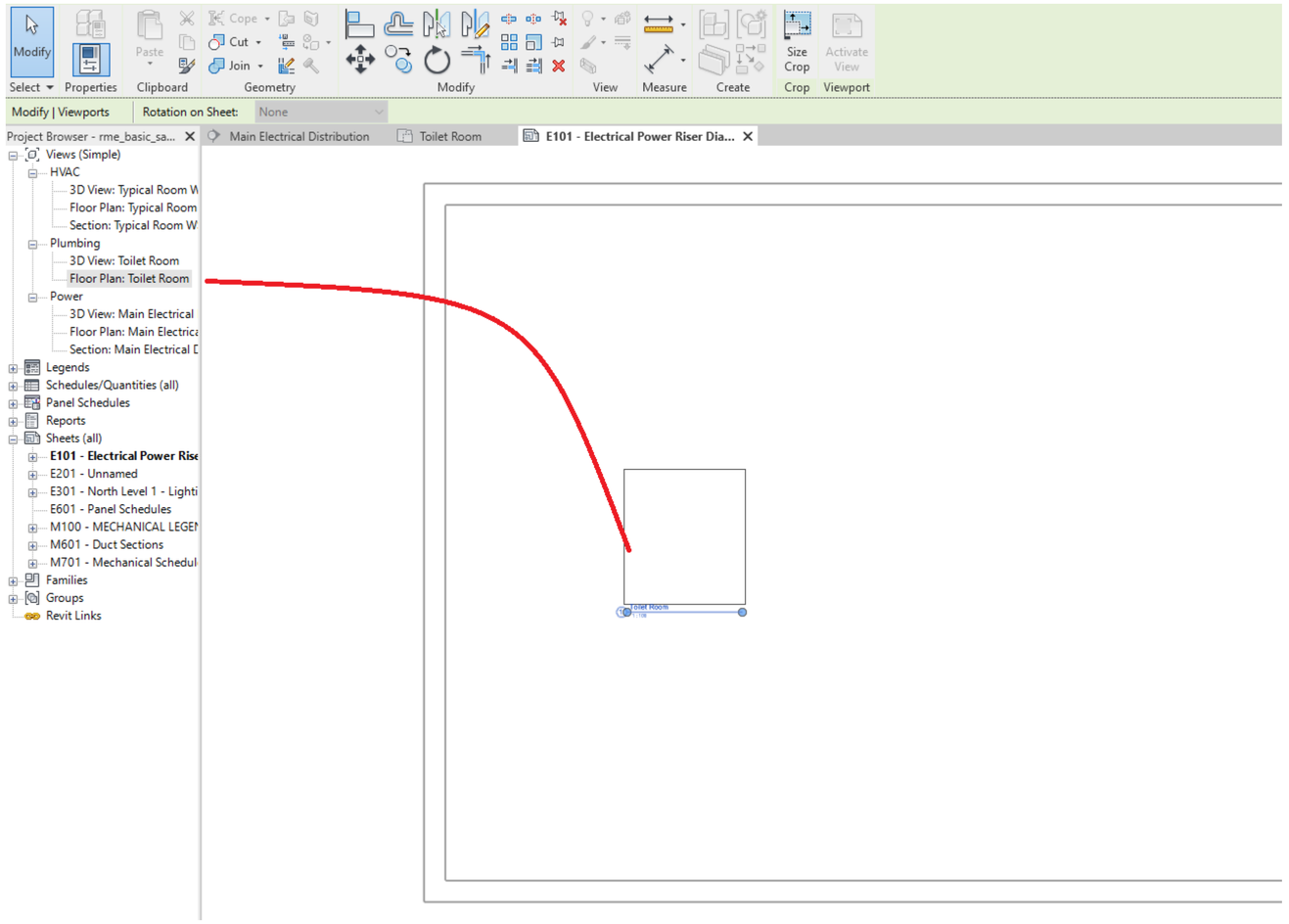
REAL CASE SCENARIO 2: AUTOMATING VIEW PLACEMENT ON REVIT SHEETS USING SUPERVISED LEARNING



View Placement – Every BIM Manager's Nightmare

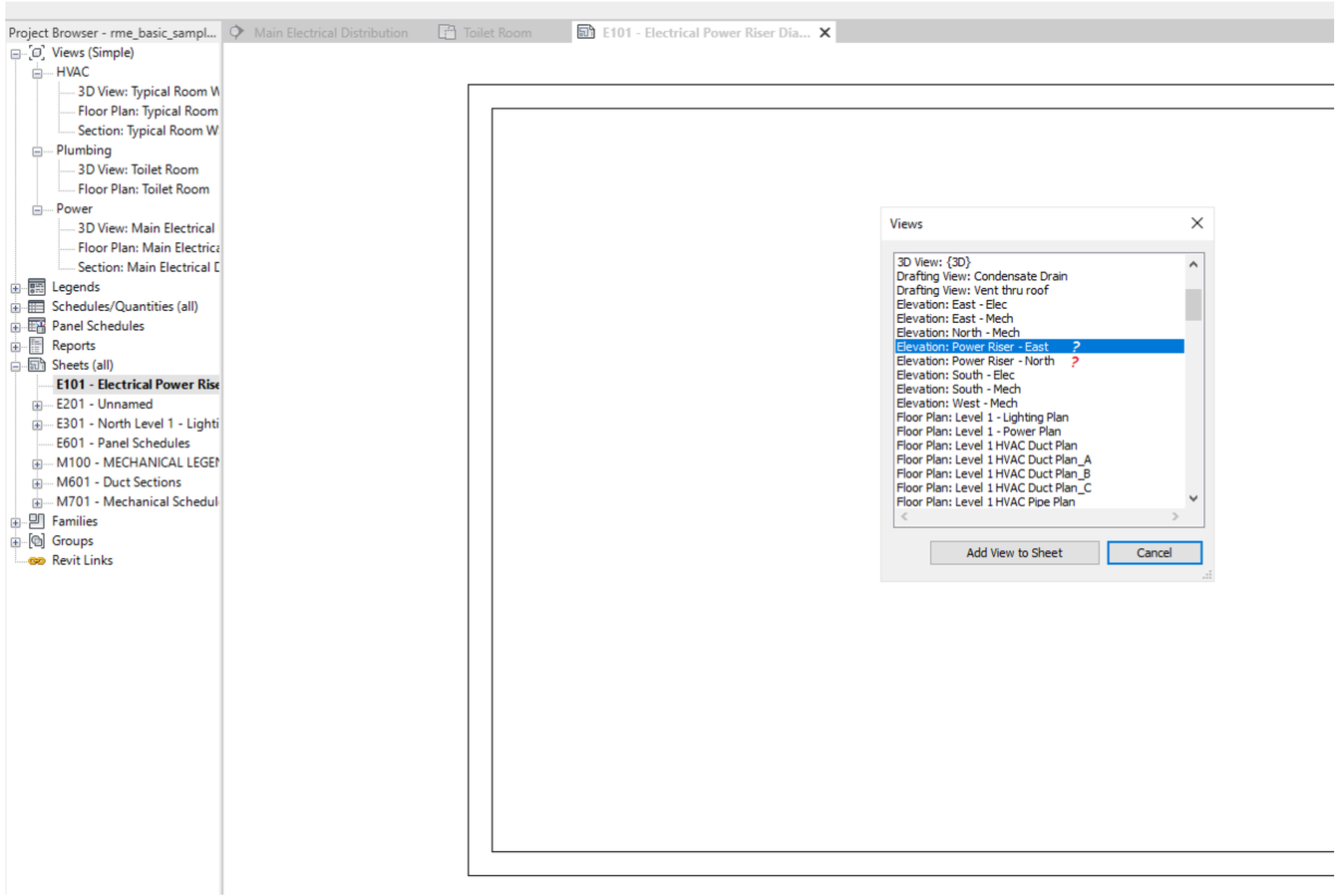
MANUAL AND TIME-CONSUMING PROCESS

1. EXPAND THE SHEETLIST AND LOOK FOR THE REQUIRED SHEET
2. OPEN EACH SHEET
3. EXPAND THE VIEWS
4. DRAG AND DROP EACH VIEW ON TOP OF THE SHEET



COMMON SOLUTIONS:

- ADD-INS THAT CREATE BOTH VIEWS AND SHEETS AT THE SAME TIME: **NOT ALWAYS AN OPTION**
- ADD-INS WITH SIMPLER UIs(Ex: TWO OPPOSED LISTS, COMBOBOXES…): **STILL REQUIRES MANUAL LABOR TO MATCH THE VIEWS WITH THE SHEETS**



MAIN PROBLEM

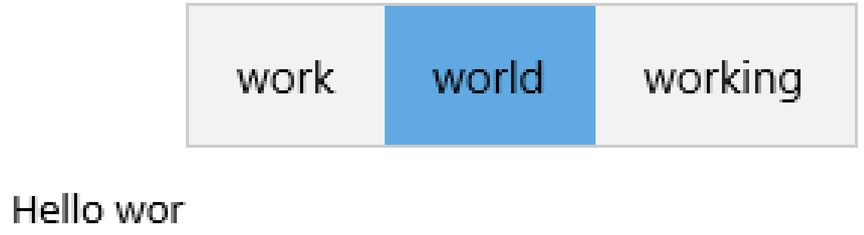
MATCHING A VIEW TO A SHEET REQUIRES HUMAN INTERVENTION: DECISION BASED ON RANDOM PARAMETRIC DATA BEING COMMON FOR BOTH THE VIEW AND ITS SHEET.

SOLUTION: SEARCH ENGINE-INSPIRED ALGORITHM

- ALGORITHM TO GATHER ALL TEXT ITEMS IN ALL PARAMETERS FOR BOTH VIEWS AND SHEETS
- EACH MATCHING VIEW ITEM IN EACH SHEET IMPLIES A HIGHER SCORE => SCORING ALGORITHM
- SHEET WITH HIGHEST SCORE => VIEW GETS PLACED

OTHER PROBLEMS ARISE...

- KEYWORDS OFTEN HAVE SYNONYMS
- MEANINGLESS WORDS AFFECTING THE FINAL RESULTS
- NON DECICIVE PARAMETERS AFFECTING THE SCORING SYSTEM



SOLUTION: PREDICTIVE TEXT-INSPIRED ALGORITHM

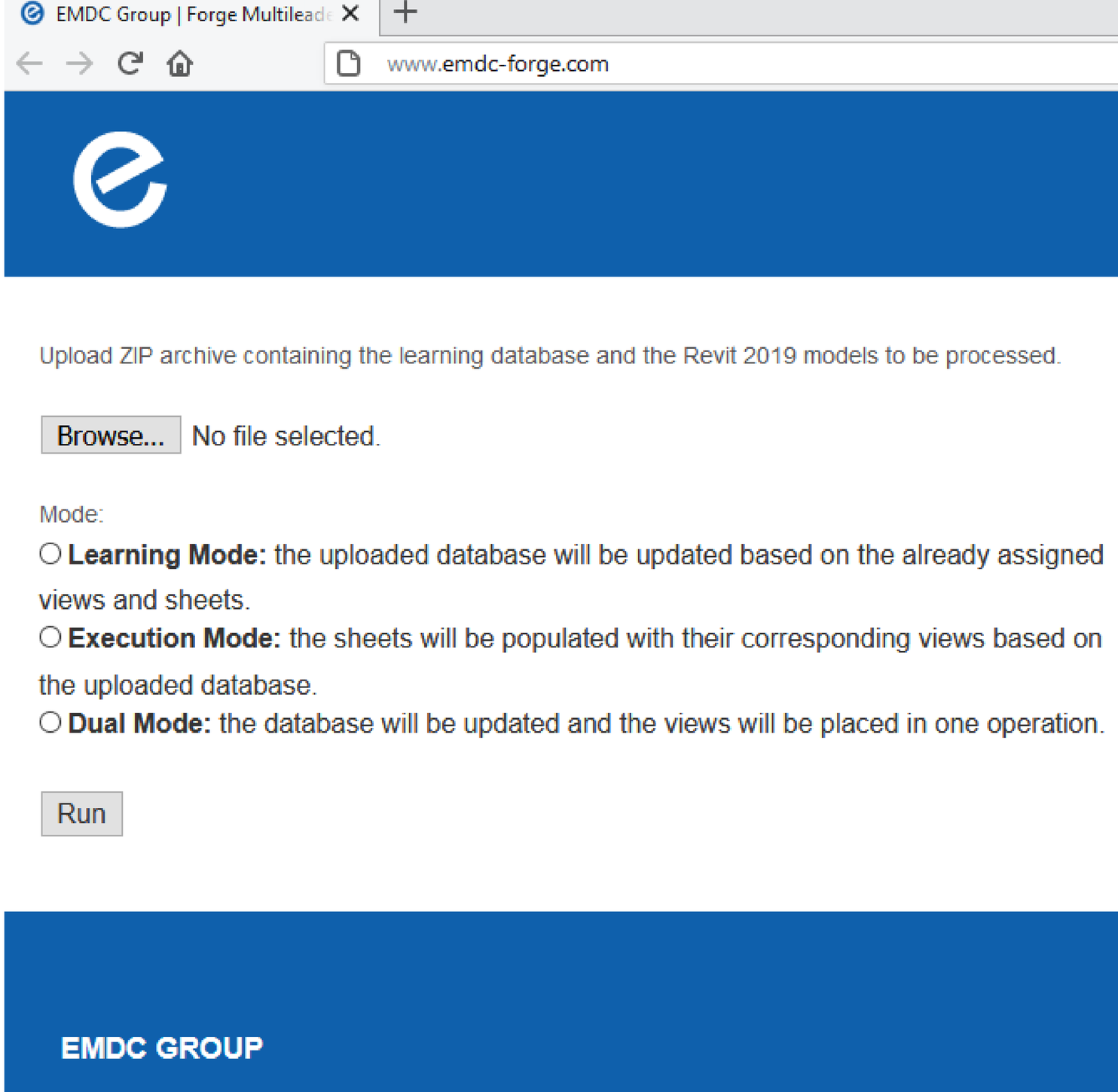
- SUPERVISED LEARNING ALGORITHM
- INPUT: REVIT MODELS WITH ALREADY ASSIGNED VIEWS
- TRAINING SET GENERATED AND KEYWORDS PAIRS GENERATED BASED ON OCCURRENCE FREQUENCY
- VIEW-SHEET MATCHING ALGORITHM USES GENERATED SET TO PROVIDE MORE ACCURATE RESULTS

WHY FORGE?

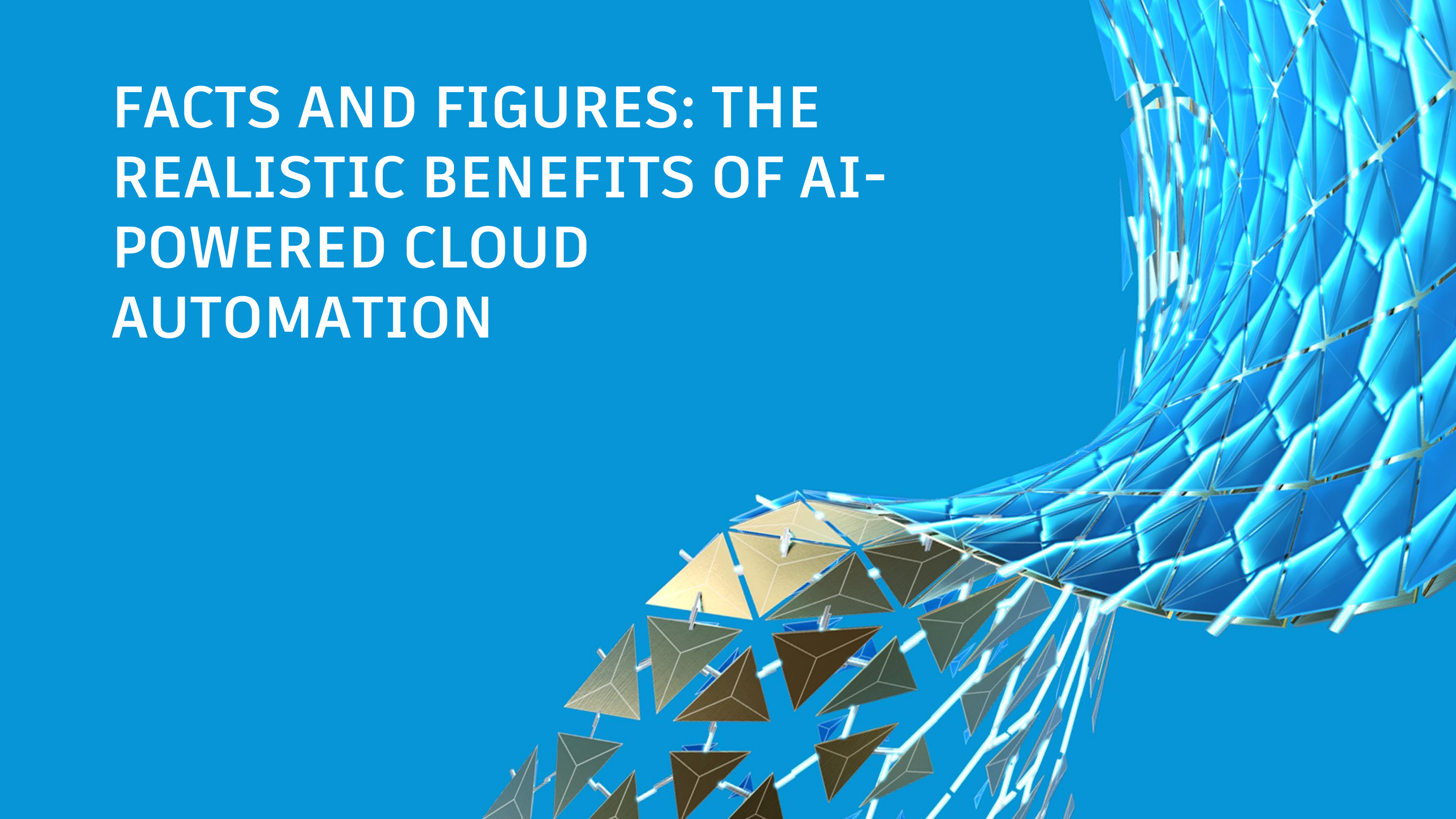
- 100,000s OF VIEWS AND SHEETS REQUIRED FOR A PROPER TRAINING
- REQUIRES MORE RESOURCES
- HIGHER EXECUTION TIME
- REQUIRES HUMAN INTERVENTION TO OPEN/CLOSE MODELS

=> FORGE DESIGN AUTOMATION FOR REVIT

- MULTIPLE MODELS PACKAGED, UPLOADED AND PROCESSED AT ONCE.
- CLOUD COMPUTING SOLUTION THAT EXECUTES REMOTELY
- MORE AVAILABLE RESOURCES AND UNIVERSALLY ACCESSIBLE RESULTS



FACTS AND FIGURES: THE REALISTIC BENEFITS OF AI-POWERED CLOUD AUTOMATION



METHODS OF WORK

MANUAL

- TIME WASTE
- WASTING HUMAN RESOURCES ON REPETITIVE TASKS

AUTOMATED

- ELIMINATES REPETITIVE TASKS.
- REDUCES COSTS
- IMPROVES THE QUALITY OF WORK
- STILL REQUIRES MANUAL INTERVENTION

AI POWERED

- ELIMINATES MANUAL WORK FURTHER
- SAVES EVEN MORE TIME
- REDUCES COST EVEN FURTHER
- REQUIRES MORE RESOURCES

FORGE POWERED

- AUTOMATES FILE ACCESS OPERATIONS
- PROVIDES A MORE POWERFUL RUNTIME ENVIRONMENT
- RESULTS UNIVERSALLY ACCESSIBLE

If *you* always *do what you've always done*, *you*'ll always get what *you*'ve always got.

HENRY FORD

FORGE + MACHINE LEARNING: STATS & FIGURES

PROJECTS/YEAR

ON AVERAGE ARE EXECUTED BY EMDC GROUP

HOURS/PROJECT

ON AVERAGE IS REQUIRED WHEN ESTIMATED WITH A FULL MANUAL EXECUTION IN MIND

HOURS/PROJECT

ACTUALLY REQUIRED WHEN COMBINING ALL AUTOMATION TOOLS BUILT INHOUSE, MACHINE LEARNING POWERED AUTOMATION PROCESSES TO MINIMIZE MANUAL, AND FORGE CLOUD COMPUTING TO MINIMIZE RUNTIME

HOURS/YEAR

OF WASTED TIME ELIMINATED AND USED TO HANDLE MORE WORK

CONSIDERABLE COST REDUCTION

INCREASED CAPABILITY FOR MORE PROJECTS PER YEAR

EMPLOYEES MORE FOCUSED ON DECISION-MAKING TASKS

QUALITY OF WORK IMPROVEMENT FOR EMPLOYEES

TIME SAVED REINVESTED IN RESEARCH AND DEVELOPMENT:
PERPETUAL PROGRESS AND EFFICIENCY IMPROVEMENT