University of British Columbia
MANUFACTURING ENGINEERING PROGRAM
FINAL EXAMINATION, December 2021

MANU 465 – AI & ML APPLICATIONS

Duration: Take-Home Exam, 12.0 hours. (7:59 AM -7:59 PM)

Materials admitted: Books, Notes, Lecture Notes, Recorded Lectures, Internet, Any Calculator, Computer, Any Software, ... (No communication with your classmates or friends about the questions during the exam time is allowed).

There are 5 questions on this test. For the written questions, you can either answer on the space provided for each question on this test paper or on a blank paper. (Please type!). The code question must be Jupyter Notebook. Zip all your files (written answers, Python Jupyter, Dataset, etc.) and submit via Canvas. Include the Dataset you used for Question 4.

The purpose of this test is to evaluate your knowledge of the course material. Orderly presentation demonstrates your knowledge most clearly, while disorganized and unprofessional work creates serious doubt. Marks are assigned accordingly.

I will be frequently checking my emails during the exam. If you run into any technical issue, send an email to me mpanah@mail.ubc.ca (for question faults or technical issues only, not for hints or guidance)

Honor Code: The exam is an individual test, and no sitting in a group or discussing the questions and solution is permitted. We trust you would follow this honor code, by signing below: "I promise to work honestly on this exam, to obey all instructions carefully, and not to have any unfair advantage over any other students."

NAME:_____   SIGNATURE:_____

STUDENT NUMBER:_____

Question	Mark Received	Maximum Mark
Q1		2.5
Q2		5
Q3		2.5
Q4		10
Q5		10
Total		30

Question 1. A short (150-200 words) essay question on Machine Learning and Ethic

Ethics is one of the most important topics to emerge in ML and AI. The ML tools have reached technological maturity, which may have impact on society, and we should be worried about its ethical implications. For example, there are stories/rumors that Amazon used its AI tool for hiring showed significant bias against female job applicants. Another story, a few months ago emerged that algorithms built to detect hate speech online have in-built biases against black people. As an engineer we would be remiss in our duty if we neglect to underscore the fact that ML can be dangerous or it can be a force for good for social ethic.

Describe an application (hypothetical or real) of AI or ML in engineering that could be unethical, causing harm to people or the environment.

Q2. Consulting a Factory in use of AI & ML for Intelligent Process Monitoring

Imagine a real-life scenario that you are hired as a consultant to assist a "Wire Nails Factory" in their quality monitoring process.

The foreman walks you through the nails manufacturing process in their facility:

Then, you are given a chance to observe different steps and machineries carefully:

After that, the QC (Quality Control) manager explains the typical issues which occur in their everyday production frequently:

One common defect is "cracking of the nail tip". If this happens, then we should shut down the equipment in time, then replace the wire. Another common problem is that the nails produced have a certain degree of inclination (i.e. the "tip and nail axis are misaligned"). This case is generally caused by the degree of wear of the blade which results in a deviation between the left and the right, consequently, leads to a situation in which the left and right are uncoordinated when the nail is made. At this time, we need to re-grind the blade in time, and adjust the operating height and reasonable position of the casing to ensure the normal operation of the nail making machine. Producing the nails with dull tip is another common issue which results in rejection of the whole batch of nails by customers.

Currently, the monitoring process is being done manually (visually or with a quick test of the tip sharpness, or random check of the nails alignment with a gage, etc.) by the QC personnel. Since the nails production is fast (over 1000 nails a minute), by the time QC realizes there is an issue and orders to shut down the factory, it is already too late, as tons of defective nails have been produced and material are wasted.

Now, you come up with a practical solution and laying out your solutions to the QC manager.
i. Clearly explain the physical quantity/quantities you would choose to measure (specify at which stage of the process or which part of the machines you would conduct the measurement); consider the practicality of this measurement. ii. The potential type of ML algorithm you may use to automate the monitoring process based on the data you would collect.

Try to be creative and come up with a "practical" solution. You may explain your solution by words and use sketches (Please limit your answer to one page or so)

Q3. Bayes Theory

We're building a prototype airplane from a batch of wood that we just purchased. There are serious risks if the mean strength of the batch is below 6000 psi (call this unfortunate event "A"). From the wood supplier we believe this risk to be only P(A)=0.03. However, we have our own wood tester, and we find that a single tested piece breaks at below 6000 psi (this unfortunate event is "T").

     We'd like to test more wood, but it is destructive testing, so we'd like to consider the probabilities associated with the test:

- The probability of breakage for a weak batch is high: P(T|A)=0.8.
- Due to the variability of wood, there is a good chance a piece will break even if the batch is ok, P(T|A')=0.1.

Considering our prior belief and new test information, what is the probability that the batch of wood is too weak based on Naïve Bayes theory?

Q4. Could an ANN/CNN learn calculus? Design and create an ANN/CNN to learn differential calculus?

Note: You are NOT asked to write any Python script or run any code, or mention how it will be done in a software. You are asked just to provide the steps (i.e. the input, output layers, deep layers, and so on). You need to explain the concept.

Hint: This question is not a straightforward question and requires some good thinking and understanding how ANN/CNN works. Start with the derivatives of fourth degree polynomials $p(x)$. The input for example could be graphs of $p = a_0 + a_1 x + \cdots + a_4 x^4$ for $0 \leq x \leq 1$ and a training set of $a's$. The correct output would be the coefficients 0, a_1, $2a_2$, $3a_3$, and $4a_4$ from $\frac{dp}{dx}$. Then, see how you can generalize this approach.

<mark>Just as a Suggestion</mark>: I think before spending lots of energy on this one, you should save your energy and first solve **Q5,** and get it done, then return back to tackle this one.

Q5. What Your Favorite Shoes Say About Your Personality?

In this question, you will make a model (Python Jupyter Notebook) to reveal the secret and tell you the other people's personality, just by taking a photo of their shoes! What about yourself, - Are you a go-getter, an attention-seeker, or a loyal friend? You can try this model on yourself to see if it predicts your personality correctly.

Resources: This is an open-ended problem; and you may conduct your own research and find relevant papers or Dataset. Here are some suggestions, but you don't have to use these.

This article explains how the type and shape of shoes are related to various personalities:

https://www.rd.com/list/shoes-personality/

You may use any source of shoes images Dataset. Just as a suggestion, you can download and use the dataset provide here. (**NOTE**: There are 50,000 images in this Folder. The images are divided into 4 major categories — shoes, sandals, slippers, and boots — followed by functional types and individual brands. The classes in this Folder have nothing to do with what we are looking after in this question. You **DO NOT** need to use all these images. Just select enough images for each of classes which you come up with (maybe based on the above article); select images that their shapes and types are close to the shapes which described in the article.

Submission (A ZIP file):

i- A Jupyter Notebook (a brief description of the project (i.e. the project goal, the number and name of classes you come up, your dataset, or any relevant information), laying out the steps, similar to what you did for the Assignments.). You should split your dataset to Training & Test sets and include how the model performs on your test set (NOTE: There will be no low grade or penalty, if your model performance accuracy is not perfect; as long as you build a logical model with enough images)

ii- The dataset you put together and used for this project.

iii- Try the model and predict your own personality (You don't have to reveal your personality to me!). For this, take a few photos of your own shoes and check it with the model. Just comment on how your model performs when you tested with your shoes. (Note: There will be no grade penalty if it does not predict your personality correctly; just comment on how it performs.)