CS 520
Homework 1
Evaluating machine learning models

Due: **Tuesday, September 17, 2019, 9:00 AM EDT**. This assignment **must** be completed individually. You may not work with others on this assignment. Each student receives an individualized version of the assignment and the answers each student provides will be different.

Late assignments will not be accepted without **prior** permission.

This assignment takes time. Do not wait until the last minute to start the assignment. Even downloading the assignment takes time. **More so than usual, it is important to start early to ensure you can complete it on time.**

Overview and goal

The goal of this assignment is to learn how software that uses machine learning can exhibit bias, and how to train machine learning models while considering their fairness aspects.

In this assignment, you will complete 3 tasks using 3 different Python machine learning tools: `scikit-learn`, `AI Fairness 360`, and `fairkit-learn`. For each task, you will be provided with a dataset and a tutorial on how to use the tool, and then asked to use what you learned to:

- Find a machine learning model that you believe will be the most accurate.
- Find a machine learning model that you believe will be the most fair.
- Find a machine learning model that you believe will best balance both accuracy and fairness.

In general, there is no "absolute best" model for any of the above goals. You will be responsible for exploring the space of model configurations to find a model that best meets each goal.

You will submit responses to questions in an on-line response form provided to you.

Tool tutorials

For each task, you will be provided with a tutorial detailing step by step how to use the relevant features of each tool to complete the task. You are required to execute the code in the tutorial, as the knowledge you acquire will be used to complete each task.

How to get started

Before beginning, make sure that you have plenty of free space (at least 20 GB) on the hard-drive of the computer you plan to use to complete the assignment.

1. To simplify installation, we have created a virtual machine with all the necessary software installed for you. To run the virtual machine, download free VirtualBox from here:
   https://www.virtualbox.org/wiki/Downloads
   and run the downloaded installer to install VirtualBox.
   If you already have VirtualBox installed, make sure you update to the current version (6.0).

2. Download the following virtual machine (VM) file from here:
   https://drive.google.com/open?id=1B0aKmMue8kQNwvs8gZgBSZBpCWrLjHFS
   This is a large file ($\tilde{6}$ GB) so you need to download it on a fast internet connection, such as the one at UMass. Plan ahead, as downloading this file late may delay your ability to complete the assignment.

3. Open the VM file in VirtualBox:

   (a) Open VirtualBox.

   (b) Go to the menu `File 〉 Import Appliance...` and select the downloaded VM file `FairML.ova`.

   (c) Click the folder icon and browse to the location of the downloaded VM file, then click `Continue`. On the next screen, leave all the default values and click `Import`. The VM (called FairML) will show up in the left pane of the VirtualBox Manager.

   (d) Double-click the VM to start it. If asked anything when starting up the VM, just press `Enter` to continue.

4. The VM will start with a window open with instructions. If the VM window is too small, do the following to adjust:

   (a) Go to `View 〉 Virtual Screen 1 〉 200%`. (If you don't see percentages when you go to the `Virtual Screen 1` menu, check for a `Scale` or something similar.)

   (b) If this doesn't work, play around with the various percentage options until the screen fits to your liking.

   Follow these on-screen instructions to start and complete the assignment.

If you accidentally close the instructions, you can re-open them from the desktop (`exercise_instructions.pdf`). If you accidentally close the web browser or VM before you're finished, you can re-run the `start_assignment.sh` script provided in the VM. You will be given the option to either keep working on the notebooks you started or start from scratch.

Using EdLab

You can complete this exercise on your own machine, but you may want to use EdLab to complete the exercise. To ssh into the EdLab machines, you need your *UMass username* and to select one of the available Linux machines to use ({*elnux1, elnux2, elnux3, or elnux7*}*.cs.umass.edu*). Whatever machine you start with, make sure you continue to useas you complete the assignment.

You will also need to download one of the following and follow the installation instructions:
X-Quartz (MacOS only): https://www.xquartz.org
X-Windows: http://www.opengroup.org/tech/desktop/x-window-system/

To use EdLab to start the exercise, do the following:

1. SSH into the EdLab machine using the following command (using your username and the appropriate machine):
   `ssh -X` *`username`*`@elnux1.cs.umass.edu`

2. Move to the CS520 directory using the following command:
   `cd ./cs520`

3. Open VirtualBox using the following command:
   `virtualbox`

4. Open VM file in VirtualBox:

   (a) Go to the menu `File` 〉 `Import Appliance...`.

   (b) Click the folder icon and browse to `/courses/cs500/cs520/cs520/` and select the VM file `FairML.ova`, then click `Continue`.
   On the next screen, modify the base folder (first drop-down menu) to your personal cs520 space – the directory should look something like this: `/nfs/elsrv4/users1/grad/bjohnson/cs520`
   Click `Import`. The VM (called FairML) will show up in the left pane of the VirtualBox Manager.

   (c) Double-click the VM to start it. If asked anything when starting up the VM, just press `Enter` to continue.

   (d) Once the VM loads, follow the on-screen instructions to get started.

If you've already started the exercise and need to finish using EdLab (e.g., you machine shuts down when you try to complete a task), do the following:

1. On your machine, export your VM by doing the following:

   (a) Go to the menu `File` 〉 `Export Appliance...`.

   (b) Select the `FairML` machine and click `Next`.

   (c) Check the `Include ISO image files` box and click `Next`. On the final screen, you can select the directory you wish to export to, then click `Export`.

2. Copy your local `FairML.ova` file to your personal space on an EdLab machine, using the following command:
   `scp /path/to/FairML.ova` *`username`*`@elnux1.cs.umass.edu:/nfs/elsrv4/users1/grad/bjohnson/cs520`

3. Follow steps 1–4 above to log into the EdLab machine and open your VM in VirtualBox.

4. Once the VM starts up, run the `start_exercise.sh` script and say yes when prompted to resume. ****If you select no when prompted to resume, a new version of the exercise will be loaded. So make sure you carefully respond to this question.****

Deliverables

Submitting your assignment will be done via the form specified in the instructions on the VM. The instructions will ask you for your `@umass.edu` email address. It is important that you use that address since everyone's assignment is unique, and to get credit we must be able to associate your work with your account.

To submit your code, you will need to properly shut down your VM. When the instructions tell you to do so, on the VM, the option to shutdown is in the `Home` menu (icon in the upper left corner of the VM Desktop). Once you have the `Home` menu open, the power button is the bottom rightmost icon. Once you click that button, a dialog box will open asking you to select shutdown. Make sure you have completed the assignment before shutting down the VM.

If you do not submit the assignment as described by the instructions on the VM, you will not get credit for the assignment.

Contact

This assignment is administered by Brittany Johnson-Matthews. If you encounter problems or have questions about the assignment, contact `bjohnson@cs.umass.edu`, and CC the professor, `brun@cs.umass.edu`. Please include **CS520** in the subject.

Troubleshooting/FAQs

Here are a few situations that may occur while trying to start or complete the assignment. If you encounter any issues you aren't able to resolve yourself, please contact Brittany Johnson-Matthews (again, cc'ing the professor).

1. **Virtual Machine hangs on a black screen on startup.**
   First thing to do is check and make sure you have the right version of VirtualBox installed (6.0). If you have any other version installed, you will need to update to the most recent version.
   If that doesn't work, try resizing the VM window smaller. You can make the VM screen bigger by changing the scale (see Step 4 in "How to get started").
   If neither of these work, check your computer and make sure you have enough memory available for Virtual Box to start up.

2. **I accidentally closed my notebook or had to leave and come back and now I don't know how to get my work back.**
   The first thing to try is re-running the `start_assignment.sh` script (see `exercise_instructions.pdf` in VM). When prompted whether you want to resume, say yes. This should open your notebook (on Task 1) with any work you've already done. ****If you select no when prompted to resume, a new version of the exercise will be loaded. So make sure you carefully respond to this question.****

3. **I closed my response form before I finished my submission.**
   You can re-access your form by using your unique URL that was sent to your UMass email when you started the exercise. If you have trouble locating your unique URL, contact Brittany Johnson-Matthews and she can send it to you.

4. **How do I make sure my response form progress is being saved?**
   Progress is saved when you click the `Next` button to go to the next page in the form. If you haven't completed the page, just enter some text in the empty boxes such that you can click the `Next` button to save. You will be able to go back (using the `Back` button or by restarting the form) to finish where you left off (make sure you don't forget!).

5. **I don't see any data points in my plot (fairkit-learn).**
   You may have to scroll through the plot area to find where the data points begin. To scroll through the plot, click and drag within the plot area.

6. **Nothing happens when I run the `start_exercise.sh` script**.
   Try executing the script using the following command:
   `bash -i start_exercise.sh`

7. **How do I evaluate fairness with scikit-learn?**
   If you would like to evaluate a model using something outside of scikit-learn (e.g., fairness metrics), you will either have to implement the metrics yourself or find a way to estimate which model will best satisfy each goal. You are also allowed to use outside resources as justification for your model selection. For example, maybe you read somewhere that model A is better than model B with respect to some

fairness metric — this can be supporting evidence for your decision. Just make sure you document that in your response form.

8. **How do I view the *Pareto frontier* based on metric X and metric Y with fairkit-learn?**
   To view the pareto optimal results of a grid search, you need to do two things: (1) select the two metrics from the drop downs for the X and Y axes, then (2) make sure the only boxes checked in the checklist of metrics are those same two metrics.