Lab 02: Introduction To C – Part 1

Assigned: 2019-01-31 08:00:00

Due: 2019-01-31 23:59:00

Instructions:

- Written portions of this assignment are submitted via Canvas. Unless specified otherwise, the written portion of the assignment is to be completed using LaTeX. All derivations, images, graphs, and tables are to be included in this document. Handwritten solutions will receive zero credit.
- Code portions of this assignment are submitted via `code.vt.edu`. Source code must be in the private repository, to which the CMDA 3634 instructors must have access.

Deliverables: For this assignment, you are to submit the following:

1. (Canvas) `<pid>_Lab_02.pdf`: A PDF file, renderd by `pdflatex` (the file generated by Overleaf is sufficient) containing the answers to the questions requiring written answers. Use the template provided in the project repository. Your submission should not exceed 2 pages.
2. (`code.vt.edu`) The source files required to compile and run your solutions to the lab and the tex and image files for your report, in the appropriate directories.

Collaboration: This assignment is to be completed by yourself, however, you make seek assistance from your classmates. In your submission you must indicate from whom you received assistance.

Honor Code: By submitting this assignment, you acknowledge that you have adhered to the Virginia Tech Honor Code and attest to the following:

> I have neither given nor received unauthorized assistance on this assignment. The work I am presenting is ultimately my own.

Background

Nearly all companies require you to use version control during code development. Version control is necessary when working in teams and for handing-off your code to other developers. Get in the habit of using version control. It will serve you well in this class, future classes, and in your jobs.

We will use a tool called Git for version control and to share code. Git is a *distributed version control system*. This contrasts with a centralized version control system, like Subversion. Git is free, open-source software, and is not just specific to the `code.vt.edu` service. The same software and commands can be used to interact with GitLab, Bitbucket, GitHub, etc.

All git commands start by running the `git` command. Some common commands that we will use in this lab are

- `git clone`: clone a remote repository
- `git add remote`: identify a remote git repository
- `git fetch`: get a branch from a remote repository
- `git merge`: merge a branch into the working branch
- `git push`: push a branch to a remote repository

Resources

- More on Git:
  - `https://www.taniarascia.com/getting-started-with-git/`
  - `http://rogerdudler.github.io/git-guide/`
- More on LaTeX:
  - `https://www.overleaf.com/learn`
- More on C programming:
  - `https://www.geeksforgeeks.org/c-programming-language/`
  - Recommended texts

Tasks

Warning: I have indicated where you should be running commands in a terminal with the > character. This character is **not** part of the command!

1. **Setup** your ssh keys for `code.vt.edu`. The directions below are adapted from here: `https://code.vt.edu/help/ssh/README.md`

   (a) Open your VM and a terminal.

   (b) Create an ssh key.

   ```
   > ssh-keygen -o -t rsa -b 4096 -C "pid@vt.edu"
   ```

   Be sure to replace `pid` with your Virginia Tech PID. Next, you will be prompted to input a file path to save your SSH key pair to. Use the suggested path by pressing Enter.

   (c) You will be prompted to input a password to secure your new SSH key pair. It's a best practice to use a password, but it's not required and you can skip creating it by pressing Enter twice.

   (d) Copy your ssh key to the keyboard.

   ```
   > xclip -sel clip < ~/.ssh/id_rsa.pub
   ```

   You may need to install xclip.

   ```
   > sudo apt install xclip
   ```

   (e) Using the browser in your VM, add your public SSH key to your GitLab account by clicking your avatar in the upper right corner and selecting Settings. From there on, navigate to SSH Keys and paste your public key in the "Key" section. If you created the key with a comment, this will appear under "Title". If not, give your key an identifiable title like Ubuntu VM, and click Add key.

   (f) Test your to see if your key is setup correctly.

   ```
   > ssh -T git@code.vt.edu
   ```

   You should receive a welcome message.

2. **Setup** your coding environment.

   (a) Install git in your VM.

   ```
   > sudo apt install git
   ```

   (b) Configure git. Be sure to use your name and PID.

   ```
   > git config --global user.name "Firstname Lastname"
   > git config --global user.email "pid@vt.edu"
   ```

   (c) In your VM, clone your assignment repository from `code.vt.edu`. We will call this the *origin* repository.

   ```
   > git clone git@code.vt.edu:CMDA3634/2019_Spring/HewettTR/cmda3634_<pid>.git
   ```

   Be sure to replace `pid` with your Virginia Tech PID. You can copy this URL from the clone link for the repository on GitLab.

   (d) Add the upstream assignment repository as a remote

```
> git remote add upstream git@code.vt.edu:CMDA3634/2019_Spring/HewettTR/cmda3634_assignments.git
```

   You can copy this URL from the clone link for the repository on GitLab.

   (e) Fetch the master branch from the upstream repository. This will contain all provided components of the lab.

   ```
   > git fetch upstream master
   ```

   (f) Merge the upstream master branch into your local repository.

   ```
   > git merge upstream/master
   ```

   (g) Push your local master branch to the origin repository.

```
> git push origin master
```

3. **Implement** the following functions and a main program that uses the functions to answer the questions below. Assume that vectors have three components x, y, and z. You may use floats or doubles for floating-point valued variables.

   Read the readme file in the `labs/lab02/code/` directory. Be sure to use git to commit your code regularly.

   ```
   > git add <your source files>
   > git commit -m "A meaningful commit message"
   ```

   (a) Create a C source file called `vectors.c`.

   (b) For the following functions you must use structs to wrap vector arguments:

      i. Define a `struct` named `Vector3D` defining a new C data type for 3-vectors.

      ii. Define a function named `norm` which computes the length of a 3-vector.

      iii. Define a function named `axpy` which computes the operation $\boldsymbol{z} = \alpha * \boldsymbol{x} + \boldsymbol{y}$, the sum of a scalar-vector product and a vector.

      iv. Define a function named `inner_product` which computes the inner (dot) product of two vectors.

   (c) Write a main function that uses the above functions to answer the questions below.

   (d) Compile your program so that the binary executable is named `vector3d`.

4. **Answer** the questions listed below. The following workflow uses Overleaf, but you are welcome to use a local tex installation if you prefer.

   (a) In Overleaf, create a new empty project.

   (b) Copy the files `lab02_report.tex` from the `labs/lab02/report/` directory to Overleaf.

   (c) Answer the questions, and upload screenshots where necessary.

   (d) In your VM, copy your report tex source and images into the `labs/lab02/report/` directory.

   (e) Add them to git, and commit them.

5. **Submit** your results.

   (a) Upload a PDF of your report to Canvas.

   (b) Push your source code and latex files to `code.vt.edu`. From anywhere in your local projects repository

   ```
   > git push origin master
   ```

   (c) Examine your assignment repository on `code.vt.edu` to be sure that all of your materials have been correctly submitted.

Questions

Answer the following questions using the latex template provided in the `lab02/report` directory of the assignment repository.

1. What command did you run to compile your program?
2. For the scalars $\alpha = 0.25$ and $\beta = 0.56$ and vectors,

$$\boldsymbol{x} = \begin{bmatrix} 1.0 \\ 1.5 \\ 2.3 \end{bmatrix}, \ \boldsymbol{y} = \begin{bmatrix} 0.01 \\ 5 \\ 17.1717 \end{bmatrix},$$

   use your program to compute the following values:

   (a) $m = \|\boldsymbol{x}\|$, the length of $\boldsymbol{x}$.

   (b) $\boldsymbol{z_1} = \alpha * \boldsymbol{x} + \boldsymbol{y}$, the `*axpy` operation for 3-vectors.

   (c) $\boldsymbol{z_2} = \beta * \boldsymbol{y} + \boldsymbol{y}$, the `*axpy` operation for 3-vectors.

   (d) $a = \langle \boldsymbol{x}, \boldsymbol{y} \rangle$, the inner product of $\boldsymbol{x}$ and $\boldsymbol{y}$ for 3-vectors.

   Include a screenshot of the output. Be sure that your output indicates which question it corresponds to.

3. Using an un-ordered list, give three (3) advantages we gained by using structures to pass the vector data to our functions.
4. Other than the instructor or TAs, who did you receive assistance from on this assignment?