Durham University

# COMP4097 Summative Assignment Part 2

## Visualisation

**Important, please read first!**

- The assignment should be submitted via Blackboard; the deadline is May $5^{th}$, 2pm. All deadlines can be found in SharePoint.
- Your software will be tested and should work with Python 3.10.2.
- Submit a compressed archive (.zip) with (a) all your source code. Your program should run by simply calling `python3 vis.py`. It should be possible to select visualisation modes from within the visualisation. Include a readme file with instructions on how to run your program and what external resources you require if this is not obvious. (b) A .pdf report no longer than 6 pages including images (max ∼2000 words). At the top of the first page of the document identify yourself using your CIS username. (c) A short video demonstrating the two visualisations and interaction (<100MB).
- The marks available for correct implementations/answers to each question are indicated. Partial credit will be given for good attempts.
- The level of achievement (good/very good/excellent/etc.) for each marking criterion is determined based on the marking and classification conventions published in the university core regulations (pp 15-16): link.
- The Visualisation sub-module contributes 50% of the total module mark and is only assessed by this coursework.
- A FAQ section in Blackboard will be updated with questions as they arise.

The year is 1996. The James Webb Space Telescope (JWST) is being designed and built and you have been hired as an intern at NASA, working on visualisation. During this preliminary design phase, you are asked to work on an interactive visualisation of the data that JWST will record. The visualisation's purpose will be *communication*, in particular for the general public. Such an easy-to-digest visualisation was deemed necessary by the science communication publicity team to help justify the cost of building JWST to the taxpayers.

JWST is an infrared telescope: Because the universe is expanding, almost all of the galaxies that we see from Earth keep moving away from us. So to us, their light (which was emitted years & years ago) appears to have a longer wavelength (think of Doppler shift for sound). We call this a **red shift**, meaning the wavelengths are more red because they are longer. For very distant objects, this red shift is so large that the interesting stuff we want to observe are now in the infrared part of the spectrum (longer wavelengths than visible). Such distant objects are also really old, because light travel takes time: the more red-shifted they are, the older they are, most of the time [1].

You have been tasked with creating a mock-up of a visualisation. Mock-up because you do not yet have any data from JWST at this point, as JWST does not exist yet! To materialise your visualisation proposal, you will have to first *simulate* the expected data, and then visualise them in a way that is accessible to the general public. To generate and visualise the data you will be using Python and the open source library VTK. You can find a lot of helpful documentation and several books in Blackboard but also in the VTK Wiki: link.

Your software will include a GUI to control certain aspects of the visualisation as required by the problem descriptions below. **Before proceeding** please make sure you watch the following two videos: [1] & [2].

PROBLEM 1 - 10 MARKS:

**Simulation.** You will first create a simulated image of the galaxies as expected to be seen by JWST. For this you will overlay many copies of a template galaxy (found in Blackboard), at different sizes, orientations and colours over a black background (simulating the darkness of the sky). Care must be taken so that galaxies do not get overwritten by other galaxies. Each galaxy will have a single pseudo-colour (in RGB), corresponding to the distance/age from us. You will be using the rainbow colour scale for this mapping. The output of this stage will be an image that resembles the Hubble deep field image [2], but would (for obvious reasons) look more artificial - this is to be expected. Write this image on the disk.

PROBLEM 2 - 10 MARKS:

**Data import.** At this stage, you will be reading back the simulated image, and using the colour values of each galaxy you will be separating them in depth, the "redder" galaxies further in the past and the bluer closer to the present, see [2].

You will read and process the data to get raw values (an arbitrary range of age/distance) based on the pixel values and colour map, writing code that will fetch the appropriate pixels from the image and store them in an appropriate for visualisation data structure in VTK.

PROBLEM 3 - 10 MARKS:

**Visualisation 1.** You will then re-project the galaxies based on their age. Your visualisation at its most basic form should resemble [2] at the 2-minute mark. The distance between galaxies in this spatial representation should be controlled using a slider for visualization purposes. Create a GUI slider to enable interactive manipulation of the scale factor and update the visualisation appropriately. Add any additional control / effects that you consider important to optimise the efficacy of the visualisation in communicating information.

PROBLEM 4 - 10 MARKS:

**Visualisation 2.** Based on the same generated dataset (from problem 2), you will create another interactive visualisation, appropriate for the general public as you see fit. The interactive visualisation could be a combination of scientific visualisation, information visualisation and info-graphics. Sky is the limit here, however, the choices made and approaches followed should be consistent with good practices for scientific and information visualisation as discussed during the lectures. Your design choices should be discussed in the report.

PROBLEM 5 - 10 MARKS:

**Report & video.** Compile a report, discussing the reasoning behind your choices for the above problems. Include images that show the simulated data and screenshots from your visualisation for different camera perspectives. Include some close-up images. All your outputs should be clearly depicted in the report. Discuss your thought process behind problem 4. Do not forget to attach a short video demonstrating your two visualisation techniques.

# References

[1] SEEKER. Why James Webb's Infrared Vision Is a Gamechanger. https://www.youtube.com/watch?v=pZBA-iQfmAI&ab_channel=Seeker, 2022. [Online; accessed 2-Feb-2022].

[2] SPACE, V. F. Hubble's UItra Deep Field in 3D is an amazing journey through space and time. https://youtu.be/2sUrauA0iq4, 2022. [Online; accessed 2-Feb-2022].