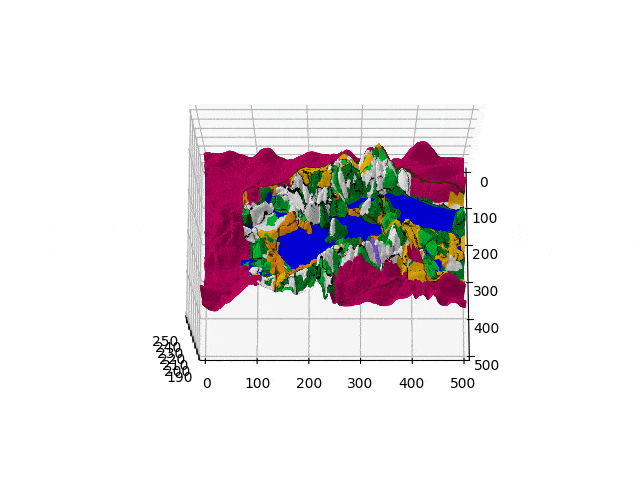
you will be generating optimal paths for orienteering during different seasons. In the sport (or "activity", depending on your level of fitness/competitiveness) of [orienteering](https://en.wikipedia.org/wiki/Orienteering#Competition_and_results), you are given a map with terrain information, elevation contours, and a set or sequence of locations to visit ("controls"). There is a combination of athletic skills and planning skills required to succeed - a smarter competitor who can figure out the best way to get from point to point may beat out a more athletic competitor who makes poor choices! you are given computer-friendly inputs so that you can use an algorithm to determine the best path for you to take depending on your ability.



**The map(s)**

In an ordinary orienteering event, the map you get will be quite detailed. Different background colors show the type of terrain (see the table below), while buildings, boulders, man-made objects and other notable features are shown with different [symbols](http://cs.rit.edu/~zjb/courses/331/proj1/legend.png). For this assignment, you are given two separate inputs, both representing Mendon Ponds Park: a [text representation of the elevations](http://cs.rit.edu/~zjb/courses/331/proj1/mpp.txt) within an area (500 lines of 400 double values, each representing an elevation in meters) and a 395x500 [simplified color-only terrain map](https://cs.rit.edu/~jro/courses/intelSys/lab1/terrain.png) (color legend below). To address the difference in width between the elevation and terrain files you should just ignore the last five values on each line of the elevation file. Also, the real-world pixel size is determined by that of the [National Elevation Dataset](http://www.sciencebase.gov/catalog/item/4f70a58ce4b058caae3f8ddb), which in our area is one third of an arc-second, equivalent to 10.29 m in longitude (X) and 7.55 m in latitude (Y).

**The basic event**

As for the points you will need to go visit, those will come in a simple text file, two integers per line, representing the (x,y) pixel (origin at upper left) in the terrain map containing the location. In the classic event type that we are considering, the sequence of points must be visited in the order given. One such classic event was the World Deaf Orienteering Championships, held in Mendon Ponds Park. The local club also had an event using the same courses, the results and maps of which can be seen [here](http://www.vmeyer.net/gadget/cgi-bin/reitti.cgi?act=map&id=209). I have done my best to convert the [white](http://cs.rit.edu/~zjb/courses/331/proj1/white.txt), [brown](http://cs.rit.edu/~zjb/courses/331/proj1/brown.txt) and [red](http://cs.rit.edu/~zjb/courses/331/proj1/red.txt) courses into the relevant text files.

**The planning**

So, you have to get to some controls. However, going in a straight line, even if possible, is often not advisable. First of all, you will be able to proceed at different speeds through different terrains. Rather than telling you how fast, you need to decide based on some representative photos how fast you can travel through these terrains:

|  |  |  |
| --- | --- | --- |
| Terrain type | Color on map | Photo ([legend](http://cs.rit.edu/~zjb/courses/331/proj1/photo-legend.jpg)) |
| Open land | #F89412 (248,148,18) | [A](http://cs.rit.edu/~zjb/courses/331/proj1/photos/A.jpg) |
| Rough meadow | #FFC000 (255,192,0) | [B](http://cs.rit.edu/~zjb/courses/331/proj1/photos/B.jpg) |
| Easy movement forest | #FFFFFF (255,255,255) | [C](http://cs.rit.edu/~zjb/courses/331/proj1/photos/C.jpg) · [D](http://cs.rit.edu/~zjb/courses/331/proj1/photos/D.jpg) |
| Slow run forest | #02D03C (2,208,60) | [E](http://cs.rit.edu/~zjb/courses/331/proj1/photos/E.jpg) |
| Walk forest | #028828 (2,136,40) | [F](http://cs.rit.edu/~zjb/courses/331/proj1/photos/F.jpg) |
| Impassible vegetation | #054918 (5,73,24) | [G](http://cs.rit.edu/~zjb/courses/331/proj1/photos/G.jpg) |
| Lake/Swamp/Marsh | #0000FF (0,0,255) | [H](http://cs.rit.edu/~zjb/courses/331/proj1/photos/H.jpg) · [I](http://cs.rit.edu/~zjb/courses/331/proj1/photos/I.jpg) · [J](http://cs.rit.edu/~zjb/courses/331/proj1/photos/J.jpg) |
| Paved road | #473303 (71,51,3) | [K](http://cs.rit.edu/~zjb/courses/331/proj1/photos/K.jpg) · [L](http://cs.rit.edu/~zjb/courses/331/proj1/photos/L.jpg) |
| Footpath | #000000 (0,0,0) | [M](http://cs.rit.edu/~zjb/courses/331/proj1/photos/M.jpg) · [N](http://cs.rit.edu/~zjb/courses/331/proj1/photos/N.jpg) |
| Out of bounds | #CD0065 (205,0,101) |  |

In addition, you will probably go slower uphill, and even slower up steeper hills. How much slower? Again, for you to decide

**Different times of year**

As you may have noticed, the landscape changes significantly throughout the year. This can have a big impact on orienteering, as the map itself indicates a sort of default terrain, but may have been made at a different time of year than the competition. (For example, this past spring, a local meet was held in which some "open land" and "slow run forest" was in fact six inches or more underwater.) So, for this part of the assignment, you will need to adapt your search process as follows (some of this is a little exaggerated, for the purposes of making an interesting assignment, but the seasonal variations are real!):

* **Summer:** the photos above were taken during summer, so we can assume the map and photos to be accurate for this season. (That is, what you have done up to this point is "summer".)
* **Fall:** In the fall, leaves fall. In the park, what happens is that paths through the woods can become covered and hard to follow. So, for fall, you should increase the time for any paths through (that is, adjacent to) easy movement forest (but only those paths).
* **Winter:** In winter, the waters can freeze. For this particular assignment, we will assume that any water within seven pixels of non-water is safe to walk on. Please note: you should **not** handle this by looking seven pixels out from every water pixel - it is much more efficient to find the edges of the waters and search out from there all at once.
* **Spring:** aka "mud season". Any pixels within fifteen pixels of water that can be reached from a water pixel without gaining more than one meter of elevation (total) are now underwater. (Note that the water pixels represent different ponds and are therefore at different heights. The best thing to do is probably to start at water pixels and search outward to the non-water adjacent, but keeping track of the elevation of the particular water pixel that you came from for each non-water pixel.) You may choose whether you wish to run through this water or not :) but note that one of the controls on the white course linked above should now be underwater! Note that if any of these alterations would make your heuristic inadmissible, you should change it!

**Input**

It should take 5 aruguments, in order: terrain-image, elevation-file, path-file, season (summer,fall,winter,or spring), output-image-filename.

Python would look like, $python3 lab1.py terrain.png mpp.txt red.txt winter redWinter.png

**Output**

For testing purposes, when your algorithm finishes, you should output an image of the input map with your path drawn on top. **Indicate which pixels you are changing due to the seaons by coloring them with a unique color.** E.g. in the winter, the water pixels you are treating as walkable should be colored differently. You should also output the total path length in meters either to the terminal or drawn on the map itself. s