CPSC-335 — Algorithms — Balloon Juice

Project #3 — The Balloon Juice of Jupiter

Introduction

Your task is to write an algorithm to find a path from the Beaux-oeuvres docking pad on Zeus Platform in the upper polar reaches of Jupiter's atmosphere up the webbed Escalante Staircase into the hidden floating Mystitonic para-balloon network and finally, hopefully, to the Mystic Balloon, which (naturally) has a mystic pool of dense orangish vapor and a puddle of mystic balloon juice at the bottom of that pool (according to the ancient Mystitonic tract found in a crypt near Malibu and partially deciphered in 1925). Many have tried, but you will be the first to send your bot into the network to success. Naturally, your bot will be reporting progress back to your ground crew at the docking pad, and thence to the world via your crowd-funded expedition webpage.

Thus, this will be a combo algorithm-and-visualization task. Specifically, your task is to display the steps your bot takes, as it takes them (except for transmission delays), in a search to find a path from the docking pad to the Mystic Balloon.

The Mystitonic para-balloons are thought to be a natural formation connected via flexible "chutes" and "swing-away webbed ladders" which the bot can traverse. A chute takes the bot on a slideway to another lower-ish balloon. A ladder takes the bot up to another higher-ish balloon, but the first rung of the ladder swings away from the starting balloon while the bot is on it – the balloon at the other end has a firm attachment to the ladder, the upshot of which is that the ladder only works in one direction. Ditto for the flexible chutes.

The Hidden Floating Mystitonic Para-Balloon Network

The Para-Balloon network is hidden from view in a curious dense area of the atmosphere, and consists of several hundred, or more, large balloon-like floating bubble structures, all connected together via tube-like chutes and tube-like webbed ladders. The first few dozen balloons have been explored and the Mystitonic fringe of each of those balloons has been confirmed.

Each balloon has a triple "fringe" of cord-like knots drooping down both from the top ceiling and from above each chute and ladder leaving that balloon. There is always a dark cord, a pale cord, and a veined cord that almost looks like an orange-red candycane – three cords in all for the fringe – and the number of knots on each is significant. According to the ancient Mystitonic tract, the fringe knot counts are read from dark to pale to veined as three "DPV" counts, and indicate the balloon to which an exit leads – or in the case of the top ceiling fringe it identifies the balloon that you are in.

The balloon at the top of the webbed Escalante Staircase is known to be DPV=(0 13 6). From there you can reach three other balloons with DPV identifiers (13 0 6), (0 12 7), and (6 13 0). Beyond this little is know, except that the tract describes how the identifiers change from one balloon to the next.

How The Mystitonic Identifiers Change

The knots "move" from one balloon to the next. The knots "move" only from one cord in your current balloon to one other cord in the next balloon. Each cord (dark, pale, or veined) has its own peculiar limits as to the number of knots it will allow: at most 19 knots for the dark cord, only 13 knots for the pale cord, and a mere 7 knots for the veined cord. It is also written that "taken together" (ie, their total) there are always 19 knots distributed among the three cords, never 20, never 18.

Further, in moving from one balloon to the next, the exit fringe is related to the current balloon's fringe in the following peculiear way. Exactly two kinds of cords will be different, and one kind of cord will be the same between the balloon's fringe and an exit fringe. For example, the dark cords may be the same for one exit fringe, but the pale cords may be the same for another exit.

Consider the initial balloon DPV=(0 13 6) and its leftmost child exit (13 0 6). Notice the P=13 knots of the initial balloon "moved" to become the D=13 knots of the exit fringe, and for the V=6 knots there was no change. This is an example of the "move all" from, in this case, current P=13 to exit D=13, and also notice that the D=13 is not above the Dark cord limit of 19 knots.

Consider the initial balloon DPV=(0 13 6) and the next child exit fringe of (0 12 7). Here, only one of the P=13 knots "moved" to increment to the exit fringe to its V=7 maximum limit number of veined cord knots. And the D=0 Dark cord remained knotless. This is an example of the "move to limit" from the Pale cord to the limit of the Veined cord.

Consider the initial balloon DPV=(0 13 6) and the third child exit fringe of (6 13 0). Here, the V=6 knots "moved" to the exit fringe's D=6 knots leaving the exit's V=0 cord knotless, and the P=13 Pale cord remained unchanged. This is another example of the "move all", from the V cord to the D cord.

From this, we can see the following meaning in the Miskitonic tract: Either one balloon fringe cord's knots will have either all moved ("move all") to a different exit cords string of knots (cord knot limits allowing) or only as many will have moved so as to bump that exit cord's knot count to reach its knot limit ("move to limit"). As the knots always move between two different kinds of fringe cord while they move from the current balloon's fringe to an exit fringe, there is always one cord kind that remains at the same count of knots for both the current balloon and that exit fringe.

Thus, for exit fringes (and their associated target balloon fringes), the Miskitonic tract indicates that exit fringes result from a "move all if under limit" or a "move enough to match limit" knot "transfer" styles, and each of the fringe cord types each has its own limit. Why the limits 7, 13, and 19 are all primes (and respectively the 3-rd, 5-th, and 7-th odd primes – making them double-primes, at that and that 19 is a triple-prime (being the 3-rd of the odd double-primes) – is still surrounded in mystery – but then, who expected a dusty old over-sized leather-bound book, the tract, to correctly predict the existence of the para-balloon network in the polar upper atmosphere of Jupiter?

To see further how these cord knot "transfer" changes work, the following data from records of prior failed explorations may help – they describe a "source" balloon fringe DPV and the exit fringe DPVs found within it, which correspond to the "target" balloon fringe found at the end of a chute tube connector or a fall-away webbed ladder connector. Note that in going from DPV=`(7 5 7)` to DPV=`(12 0 7)` that we have no immediate connector back – there is not always a backward connecting linkage.

```
(0 13 6) ==> ((13 0 6) (0 12 7) (6 13 0))
(0 12 7) ==> ((12 0 7) (0 13 6) (7 12 0))
(7 12 0) ==> ((0 12 7) (6 13 0) (19 0 0) (7 5 7))
(7 5  7) ==> ((0 12 7) (12 0 7) (7 12 0) (14 5 0))
(12 0 7) ==> ((0 12 7) (12 7 0) (19 0 0))
(14 5 0) ==> ((7 5 7) (6 13 0) (19 0 0) (14 0 5))
(6 13 0) ==> ((0 13 6) (19 0 0) (6 6 7))
```

Balloon Juice

The goal is to reach the Mystic Balloon, reputedly deep in the Para-Balloon network, collect a small sample of the balloon juice reputed to be there, and then return to the Beaux-oeuvres docking pad. All the while, your crowd-source investors (who funded this amazing adventure) will be able to watch your bot explore parts of the amazing floating Mystitonic para-balloon network.

The Mystic Balloon is believed to be the balloon identified through Multi-spectral scans as DPV=(3 13 3), but we don't know exactly how deep into the para-balloon cluster it is, or even if it is truly

reachable from the Beaux-oeuvres docking pad – though the tract says it is reachable & back again.

As your bot moves from one balloon to the next, you should show each balloon the bot enters and how it is known to be connected to the other balloons. We recommend your webpage be prepared to display up to 40 balloon locations with at least four connections/exits from each balloon. We are not aware of balloons with more than 4 exits, but not all balloons have been explored. Multi-spectral scans have indicated that this polar para-balloon cluster appears to have about 40 balloons. We further recommend that you use shallow (high-radius) circular arcs to represent linkages between balloons on your webpage and circles or disks (annotated with the balloon fringe DPV identifier) for each balloon visited. Other ways of displaying the developing (as explored by the bot) graph are also allowed.

If you would rather put 2-digit index numbers to indicate visited balloons and provide a translation table from index number to DPV identifier, that would also be okay.

Also, show your bot traveling from one balloon to the next, perhaps also with highlighting the source and target balloons during its traversal. (No special display is needed for the chutes or fall-away ladders.)

In addition, you should also keep track of, and display, the shortest path found between each pair of visited balloons – whether they are connected or not. This should be displayed like the format of an adjacency matrix (and you may recall constructing something like this using the Floyd-Warshall algorithm for all-pairs shortest paths – but you do not need to show all pairs, but only the visited pairs, as they become visited).

You may use any on-the-fly search algorithm you like in having your bot look for the Mystic Balloon, but note that as you have a physical bot, it cannot merely hyper-jump from the balloon through a non-existent exit to some unconnected balloon. (The good news is that there is no dead end in the para-balloon network – so says the Miskitonic tract: “It was for-ordained by the Old Twos that all globes are reachable from all other globes.” (It doesn't say who or what the “Old Twos” were.)

Further, your choice of which exit to take must be based on some simple mechanism (eg, roll a die, use a simple heuristic function based on the fringe DPVs you have seen and the goal balloon DPV, or some other simple finite state machinery). You **can** use the prior failed exploration data, shown above, if you wish. In particular, it cannot be based on some clever global analysis (pun intended) from the tract balloon-exit cord knot “transfer” rules – it is known that such global knowledge has destroyed all prior expeditions, so your bot is intended to be a knowledge-lite bot to avoid the wrath of the Old Twos.

(BTW, those source-target pairs represent about 16% of the tract-alleged network, so that is a pretty good head start on the prior expeditions.)

Running Time Analysis as before.

Team

The team size is the same as before, but you can change teams and names if you wish.

Academic Rules,Project Reporting Data, Readme File, Submission & Readme File, Grading

Same as for Project #1.