0.1 Robustness

To test the model's robustness we created custom patches with different features, walls,bumps,ramps, and test the model's predictions against the real robot advancement obtained from the simulator. Hopefully, model's outputs should match the ground truth or show a degree of uncertainty in the edge cases. According to the previous experiments, we used a threshold of 20cm and a time window of two seconds.

0.1.1 Untraversable wall ahead at increasing distance

The most trivial test is to place a not traversable wall in front of *Krock* at an increasing distance from the its head. At a certain distance, we expect the model's predictions to be traversable even if the wall itself is too tall. Why? Because the robot will be able to travel more than the threshold before being stopped by the obstacle.

We created fifty-five different patches by first placing wall 16cm long exactly in front of the robot and then move it by 1cm at the time towards the end. It follows some of the input patches ordered by distance from the robot. We remind to the reader that Krock traverse the patch from left to right.

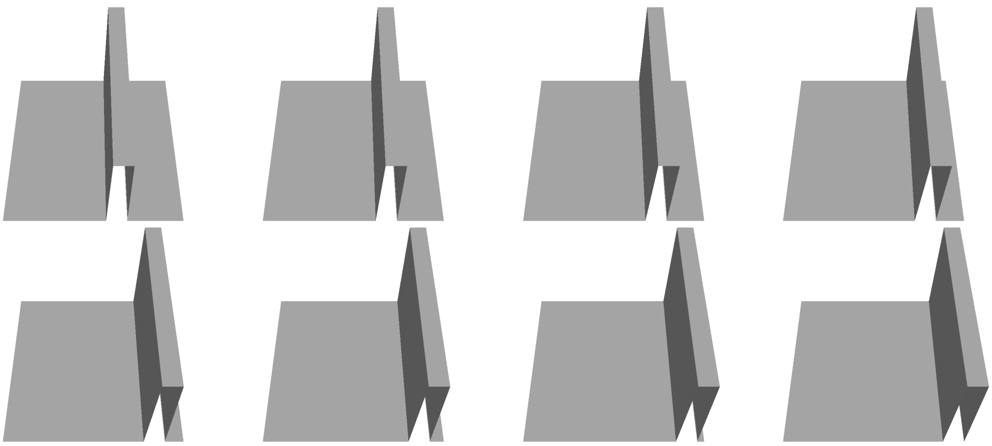


Figure 1. Some of the tested patches with a non traversable wall at increasing distance from the robot.

The model's predictions are shown in the following plot. We can see how the two classes invert their values around 20cm. Moreover, the predictions are uniform and do not change multiple times. Intuitively, if a wall is traversable from a certain distance, it will still be if we place even further.

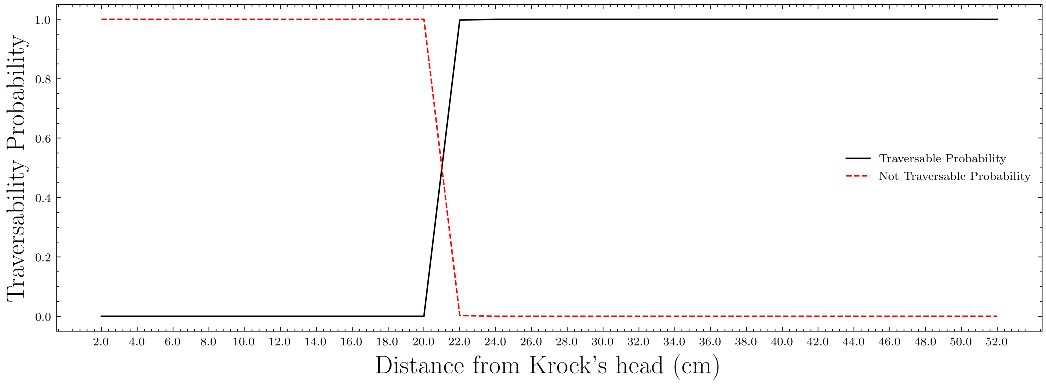


Figure 2. Traversability probabilities against wall distance from Krock's head.

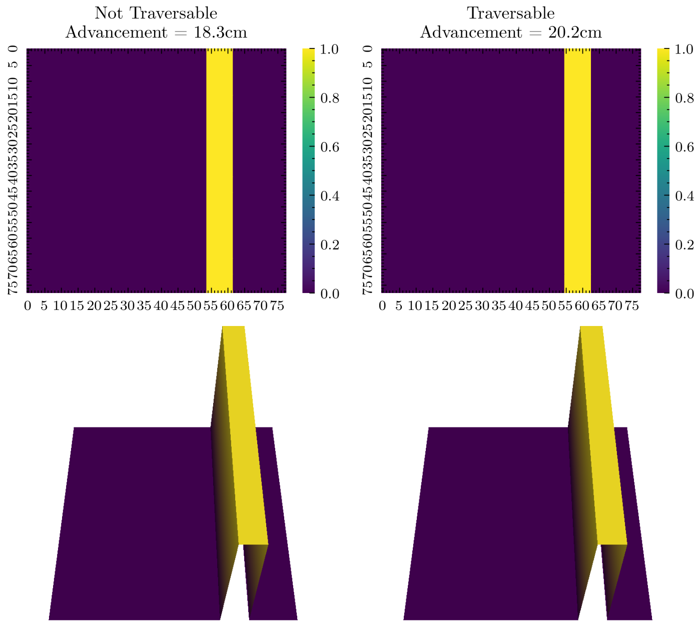
graph too tall, adjust the figure size

Summarized by the following table:

Distance(cm)	Prediction
0 - 20	Not traversable
22 - end	Traversable

Table 1. Model prediction from the wall patches.

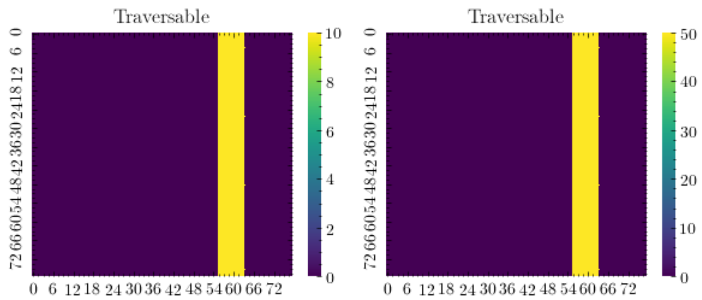
To be sure the results are correct, we run the last not traversable and the first traversable patch on the simulator to get real advancement. In the simulator, Krock advances 18.3cm on the first not traversable patch **??** (a) where the wall is at 20cm from the robot's head. While, on the first traversable patch, with a wall at 22cm, the robot was able to travel for 20.2cm. Correctly, the network's predictions are supported by the ground truth obtained from the simulation. Moreover, the model correctly undestand that the distance from the obstacle is more relevant than its height.



(a) Distance 20cm (b) Distance 22cm

Figure 3. Correctly, when the distance between the robot and the wall is greater than the select treshold, in our case 20cm, the patch is label as traversable.

Furthermore, we increased the wall size of the first traversable patch, figure **??**(b), to 10 and to 50m to see if the model will be confused. Correctly, the predictions did no change and those patches were still labeled as traversable



(a) height = 10m (b) height = 50m

Figure 4. Two patches with a very tall wall at a distance $> tr$.

Correctly, the model classifies the patches as traversable and was not confused by the enourmous height of the two walls.

0.1.2 Increasing height walls ahead

An other test we performed was to place walls in front of the robot with increasing heights to check whether the prediction matches the real data. We run forty patches in the simulator from a wall's height of 1cm to 20cm. The following figure shows some of the inputs.

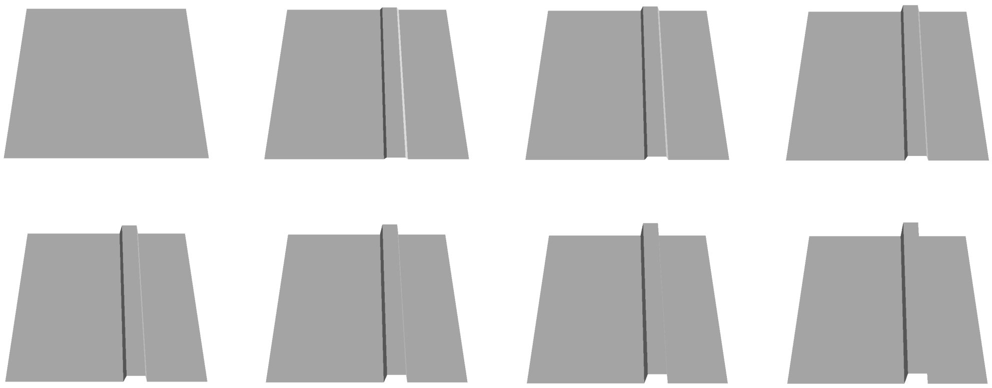


Figure 5. Some of the tested patches with a wall at increasing height ahead of Krock.

The models predicted that the walls under 10cm are traversable. We can see that in the edge case, $\approx$ 10cm, the model's prediction change smoothly revealing a degree of uncertanty.

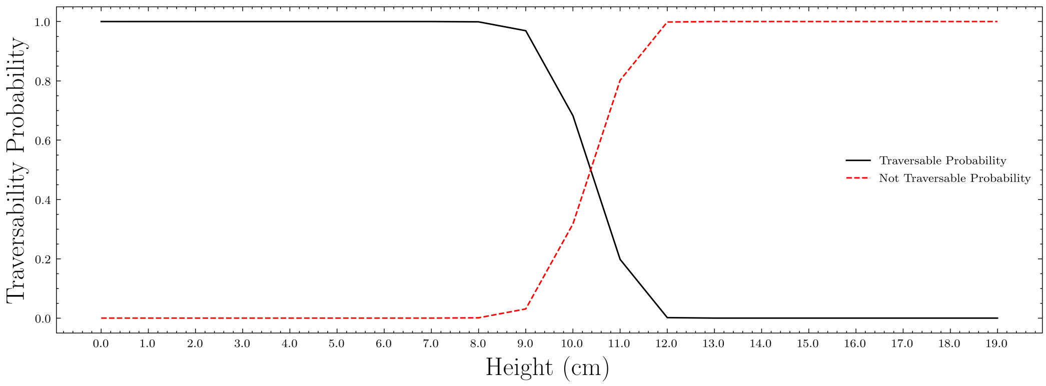
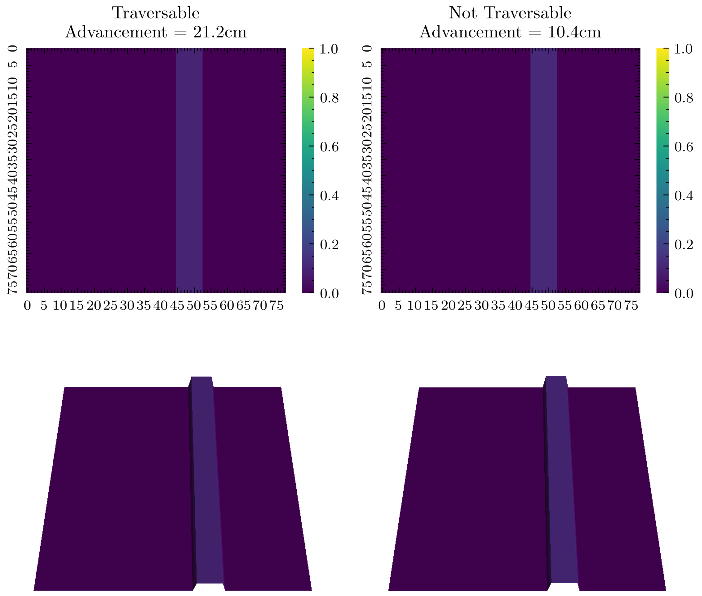


Figure 6. Traversability probabilities against walls height in front of Krock.

Height(cm)	Prediction
0 - 9	Traversable
10 - end	Not Traversable

Table 2. Model prediction for the wall patches

We can compare the model's prediction with the advancement computed in the simulator using the same approach from the last section. The following figure shows the results from the last traversable patch and the first non traversable.



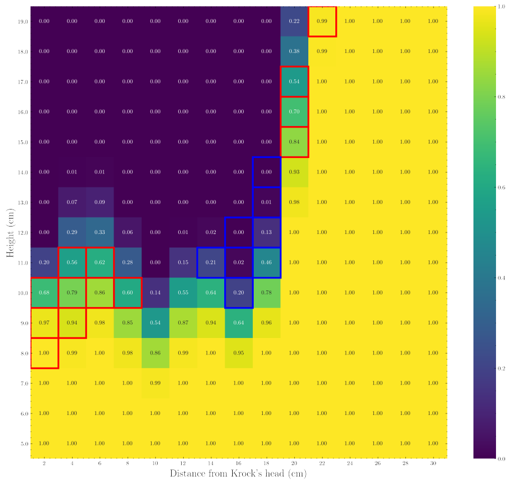
(a) height 9cm (b) Height 10cm

Figure 7. The last traversable and the first non traversable patches with a increasing height wall ahead of Krock. Correctly the model's prediction matches the advancement from the simulator.

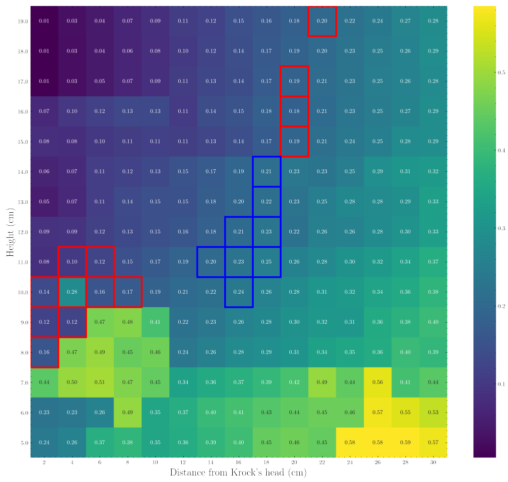
In the first case, the simulator outputed and advancement of 21.2cm meaning that Krock was able to overcome the obstacle, while it failed in the second case. Correctly, the predictions matched the real data.

0.1.3 Increasing height and distance walls ahead.

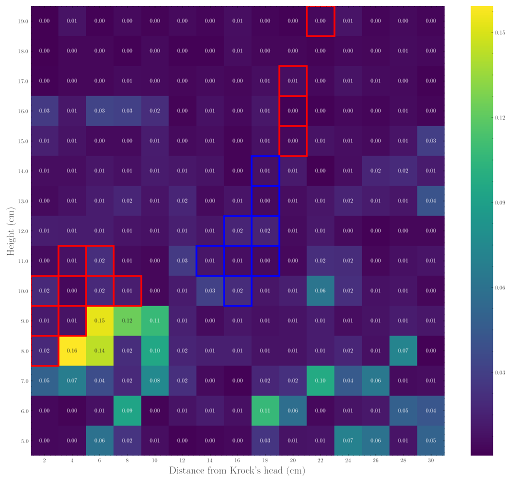
We combined the previous experiments and tested the model predictions against the ground truth for each height/distance combination. To reduce the number of samples and improve readability, we limited ourself to consider only patches with a wall tall between 5cm and 20cm, we know from previous sections patches with a value smaller and bigger obstacle are traversable and not traversable respectively. Similar, we set the wall's distance from Krock's head between 1cm to 30cm for the same reasons. To evaluate the model's prediction, we run all the patches several time on the simulator and average the results. We highlighted the false positive and the false negative by red and blu respectively. Since we spawned the robot directly on the patch inside the simulator, the outputs may change across different runs. Sometimes, two runs on the same patch can produce different advancement due to some really small changes in the initial position of the robot caused the spawing procedure or some lag. So, to completness, we also shown the variance between all simulation's runs to highlighted cases where the advancement changes the most across different runs.



(a) Predictions



(b) Averaged real advancement



(c) Standard deviation of the real advancement

Figure 8. TODO

The model's fails to predicts some of the edge cases. The false positive are located in two regions: on the bottom left and on the top center. The first are the patches with a wall just ahead Krock of heights between $\approx 8 - 11$combination. The second cluster of false positive appears when the wall is at 20cm, the treshold. Even if the model failed to classify those inputs, it shows a correct degree of uncertainty.

The false negative, in the middle, are the inputs at distance close to the treshold and with a wall near the edge between traversable and not traversable. The overall accuracy is 91%. Even if the model wrongly classified some of the inputs, all those errors are in the edge cases where the predicted classes' probability is not maximum. Moreover, in most cases the model's shown uncertainty, especially on the false negative. Also, the prediction changes smoothly without any spikes accordendly to the features of the terrain. This shows a correct degree of understanding of the surface inputs. For instance, If the model outputs not traversable at height of 10cm and at distance of 16cm, then all the taller wall are correctly labeled as not traversable showing consistency and predibility.

FINISH

0.1.4 Tunnel

do it

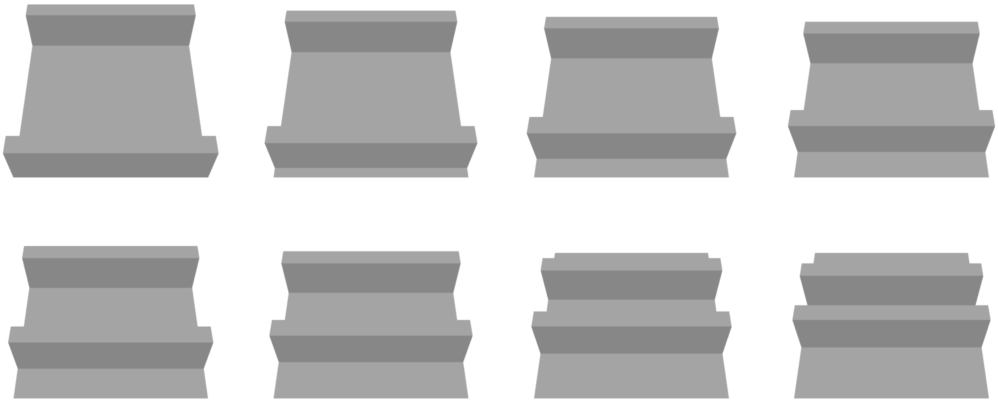


Figure 9. Some of the tested patches with tunnel at different distances.

0.1.5 Ramps

explain we had to square the linear ramps to create a small flat region

We generate twenty ramps with a maximum height from 0.25m to 4m. Below we plot the traversability probabilities against the maximum height of each ramp.

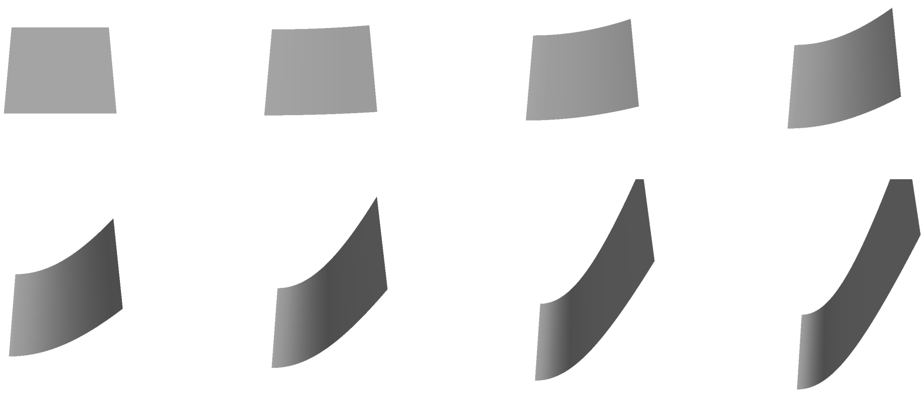


Figure 10. Some of the tested patches with steep ramps.

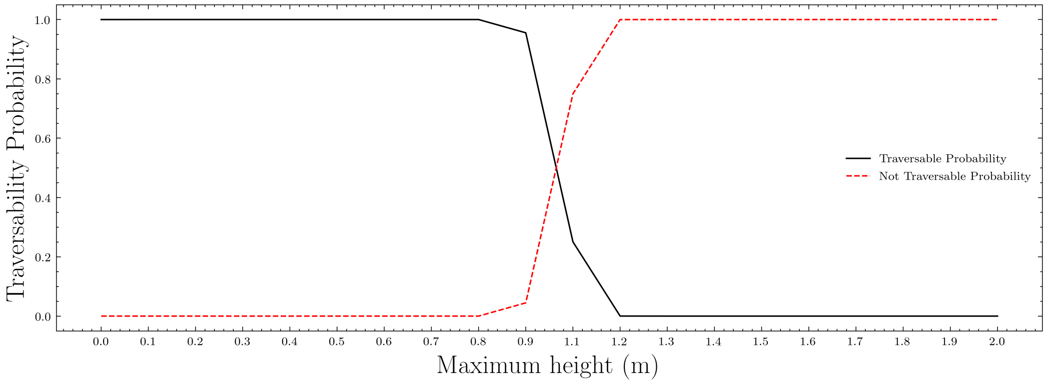


Figure 11. Traversability probabilities against maximum height of each ramp.

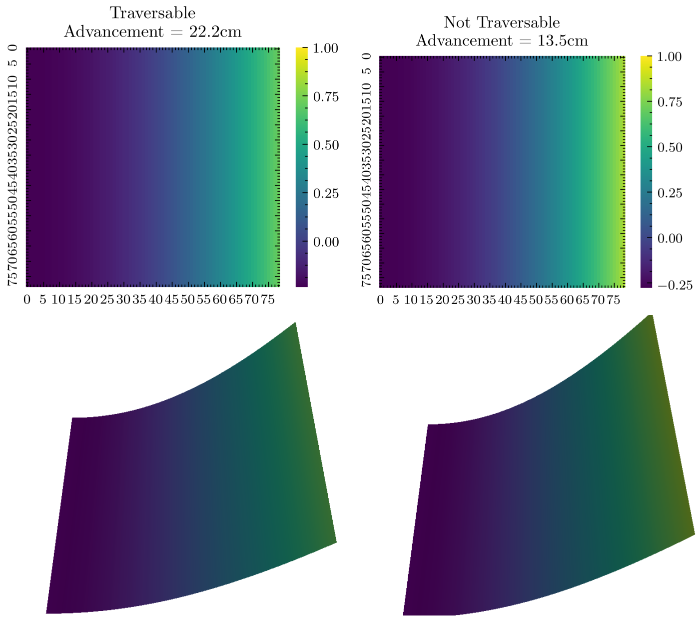
x labels are wrong, why?

The following table summarizes the results.

Height(m)	Prediction
0.5 - 1	Traversable
1 - end	Not traversable

Table 3. Model prediction for the ramps patches

We test the last traversable patch and the first not traversable with the real advancement gather from the simulator.



(a) Height 0.94cm (b) height 1.1m

Figure 12. The last traversable and the first non traversable patches with a steep ramp ahead of Krock.

scale is wrong

Krock is able to traverse up to $1m$ height ramps, this is confirmed using the simulation. We can add rocks to those patches to give Krock the ability to climb them better.

add rocks

0.1.6 Holes

do it