0.1 Robustness

To conclude the investigation of the network's abilities, we tested the model's robustness on patches with different features, walls, bumps, ramps, and examined the model's predictions against the real robot advancement obtained from the simulator. In general, the model's outputs matched the ground truth. When it fails, on some edge cases, it showed a certain degree of uncertainty. According to the previous experiments, we used a threshold of twenty centimers and a time window of two seconds.

0.1.1 Untraversable wall ahead at increasing distance

We first test we performed was to place a not traversable wall in front of *Krock* at gradually moving towards the end. At a certain distance, we expected the model's prediction 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. Figure **??** shows some of the inputs patches ordered by distance from the robot. We remind the reader that Krock traverse the patch from left to right. The model's predictions are displayed in figure **??**. We can see how the two classes invert their values around 20cm. Moreover, the predictions are consistent 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.

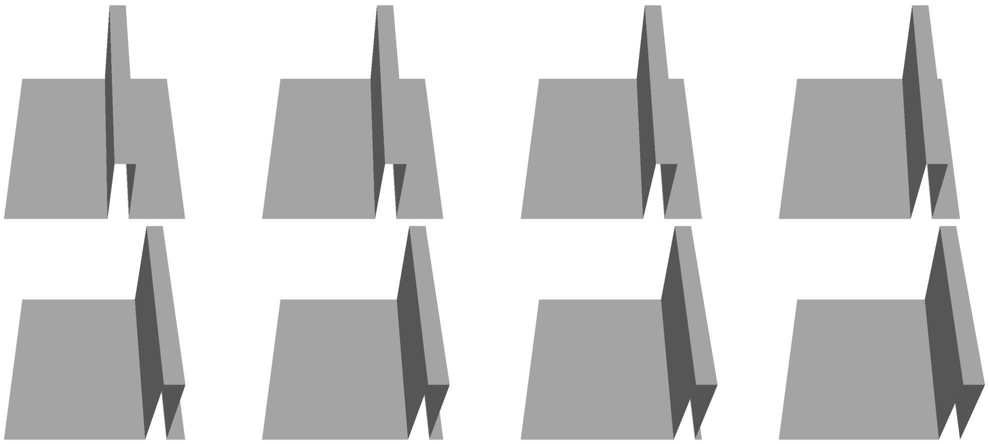


Figure 1. Some of the tested patches with a non traversable wall at increasing distance from the robot.

graph too tall, adjust the figure size

Summarized by the following table: 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,

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

Table 1. Model prediction from the wall patches.

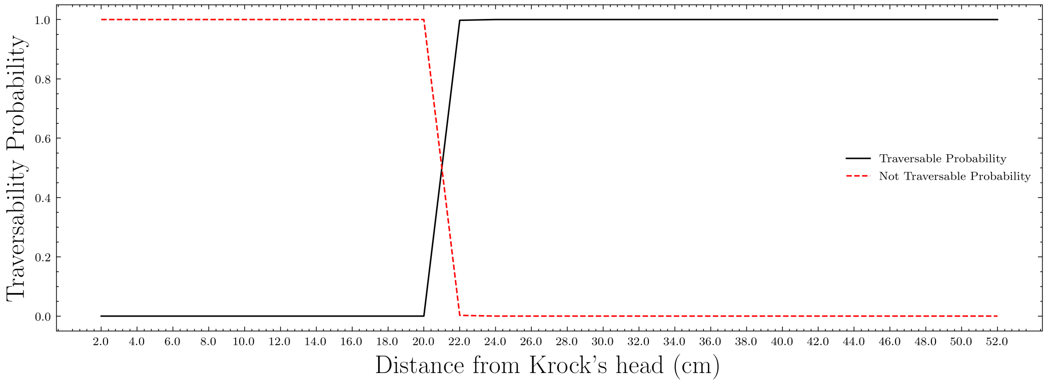


Figure 2. Traversability probabilities against wall distance from Krock's head.

Krock advances 18.3cm on the first, not traversable patch **??** where the wall is at 20cm from the robot's head. While, on the first traversable patch, figure reffig :walls-traversable-b, 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. Even more important, the model understood that the distance from the obstacle is more relevant than its height. Furthermore, we increased the wall size of the first traversable patch, figure **??**, to 10 and to 50m to see if the model will be confused. Accurately, the robot was not confused by the enourmous wall and the predictions did no change and those patches were still labeled as traversable. Figure 4 visualize those patches.

0.1.2 Increasing height walls ahead

After we tested the distance from Krock's and a wall, we decided to fix the obstacle position but increase its heights. We run forty patches in the simulator with a wall place exactly in front of the robot with height from 1cm to 20cm. Figure 5 shows some of the inputs.

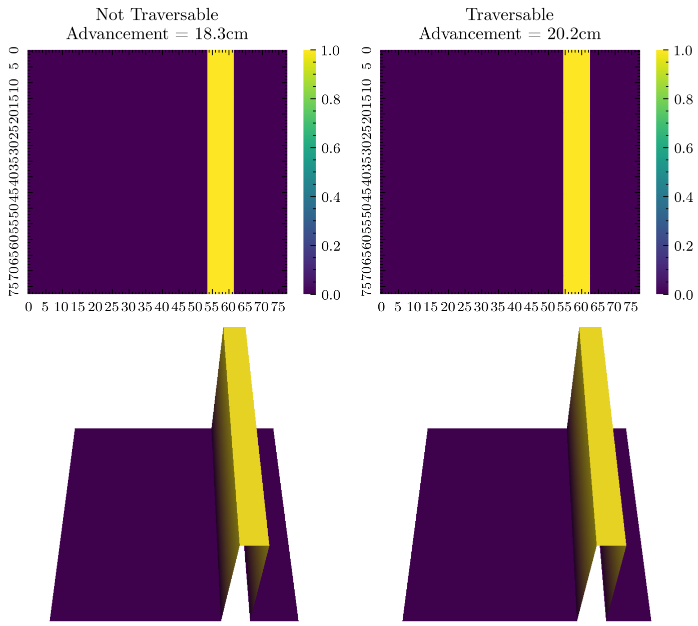
The models predicted that the walls under 10cm are traversable. We plotted the classes probabilities in figure 6 in which we see that in the edge case, $\approx$ 10cm, the model's prediction change smoothly revealing a degree of uncertainty, positively the estimator outputs to change smoothly.

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

Table 2. Model prediction for the wall patches

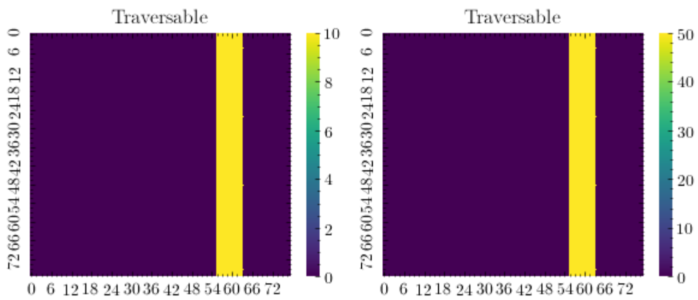
We compared the model's prediction with the advancement computed in the simulator using the same approach from the last section. Figure **??** shows the results from the last traversable patch and the first non traversable.

In the first case, the simulator outputted 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.



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

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



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

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

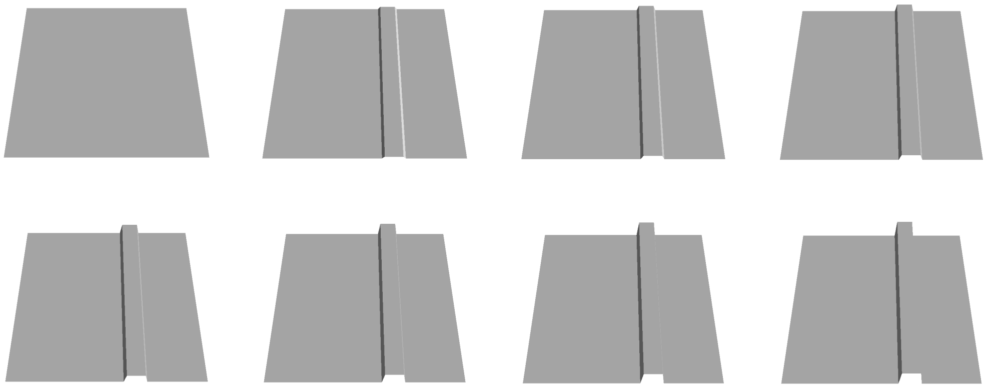


Figure 5. Some of the tested patches with a wall at increasing height ahead of Krock.

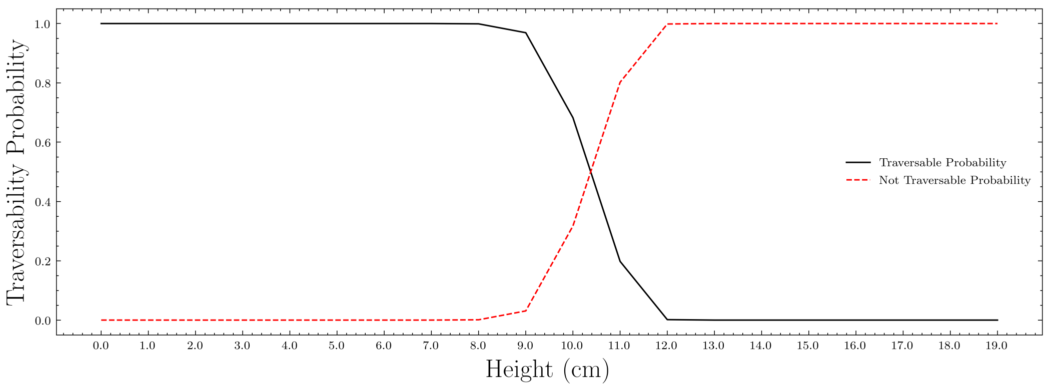
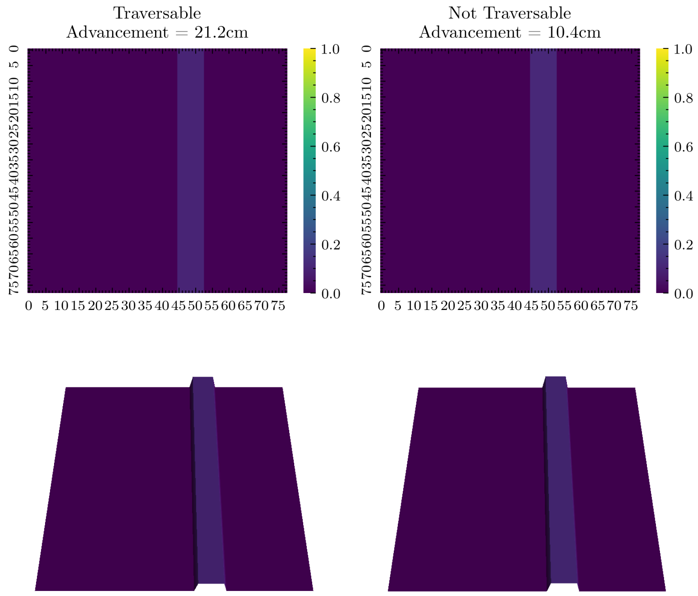


Figure 6. Traversability probabilities against walls height in front of Krock.



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

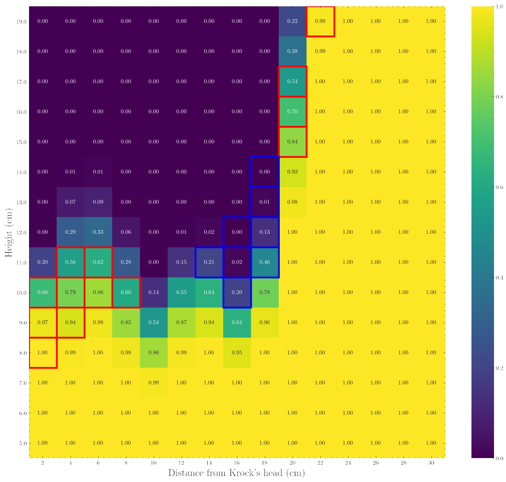
Figure 7. The last traversable and the first not traversable patches with a height wall of increasing height ahead of Krock. Correctly the model's prediction matches the advancement from the simulator.

0.1.3 Increasing height and distance walls ahead.

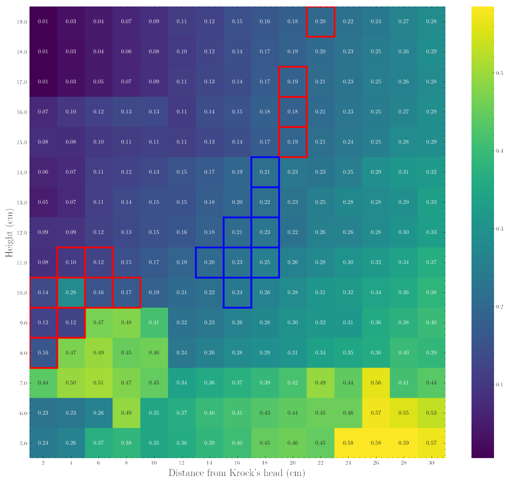
We combined the previous experiments and tested the model predictions against the ground truth for each height/distance combination. To reduce the number of samples and improve readability, we limited to consider only patches with a wall tall between 5cm and 20cm, we know from previous sections patches 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 times on the simulator and average the results. We highlighted the false positive and the false negative by red and blue 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 spawning procedure or some lag. So, for completeness, we also display the variance between all simulation's runs to highlighted cases where the advancement changes the most across different runs.

The model failed to predict some of the edge cases. The false positives are located in two regions: on the bottom left and on the top center. The first ones 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 threshold. Even if the model failed to classify those inputs, it shows a correct degree of uncertainty.

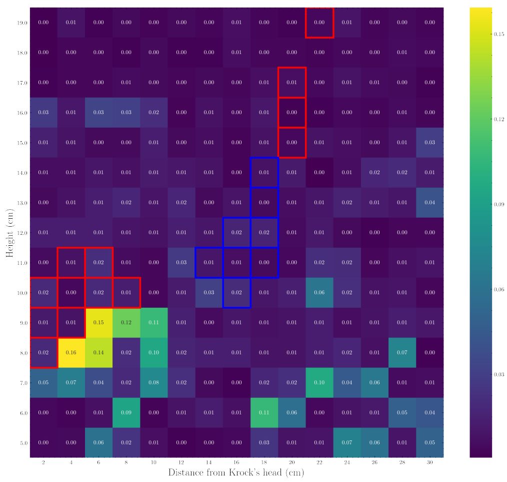
The false negative, in the middle, are the inputs at distance close to the threshold and with a wall near the edge between traversable and not traversable. The overall accuracy is 91%. Even if the model wrongly classified some of the inputs, all those errors are in the edge cases where the predicted classes' probability is not maximum. Moreover, in most cases, the model's shown



(a) Predictions



(b) Averaged real advancement



(c) Standard deviation of the real advancement

Figure 8. TODO

uncertainty, especially on the false negative. Also, the prediction changes smoothly without any spikes accordingly 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 a distance of 16cm, then all the taller wall are correctly labeled as not traversable showing consistency and predictability.

FINISH

0.1.4 Tunnel

do it

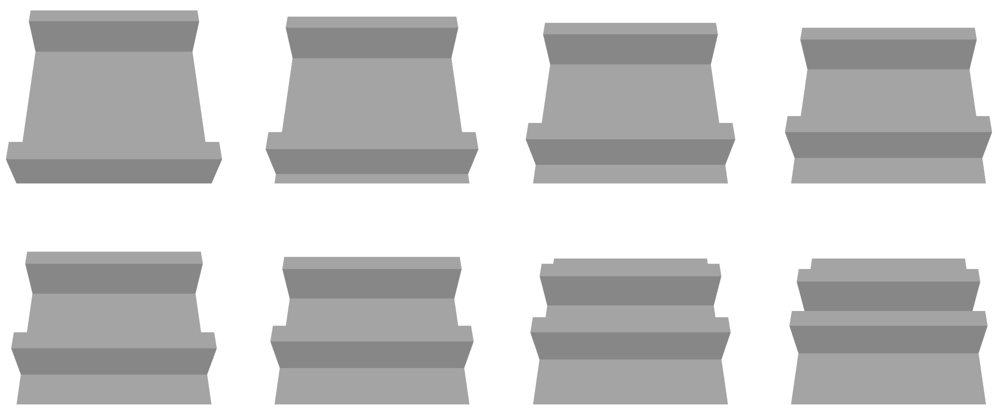


Figure 9. Some of the tested patches with tunnel at different distances.

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.

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.

scale is wrong

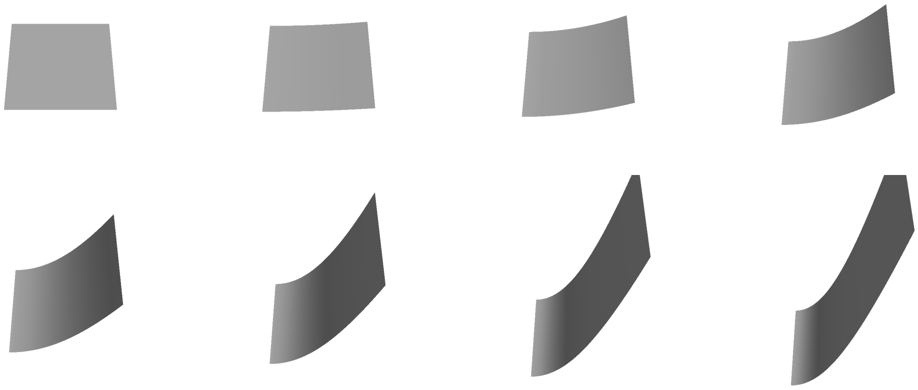


Figure 10. Some of the tested patches with steep ramps.

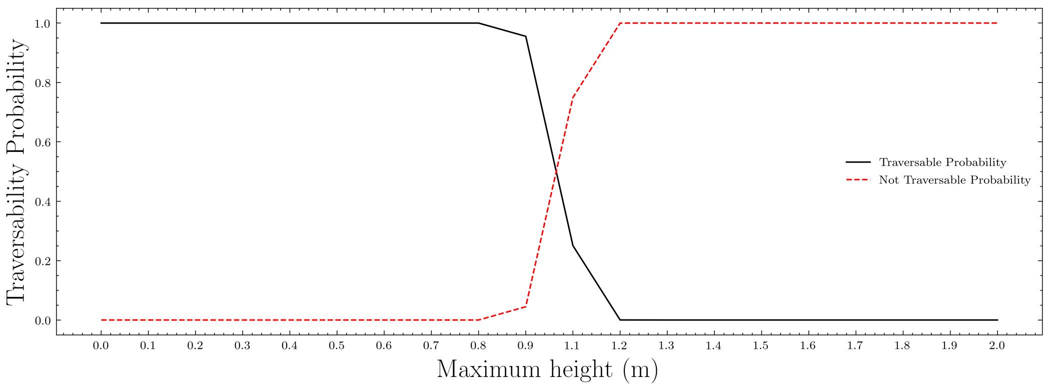
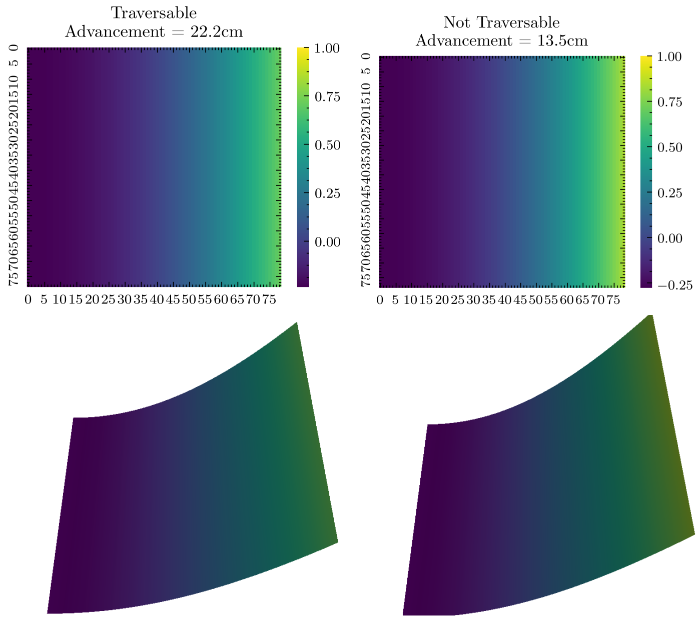


Figure 11. Traversability probabilities against maximum height of each ramp.



(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.

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