Generating Landmark Navigation Instructions from Maps as a Graph-to-Text Problem

Anonymous authors
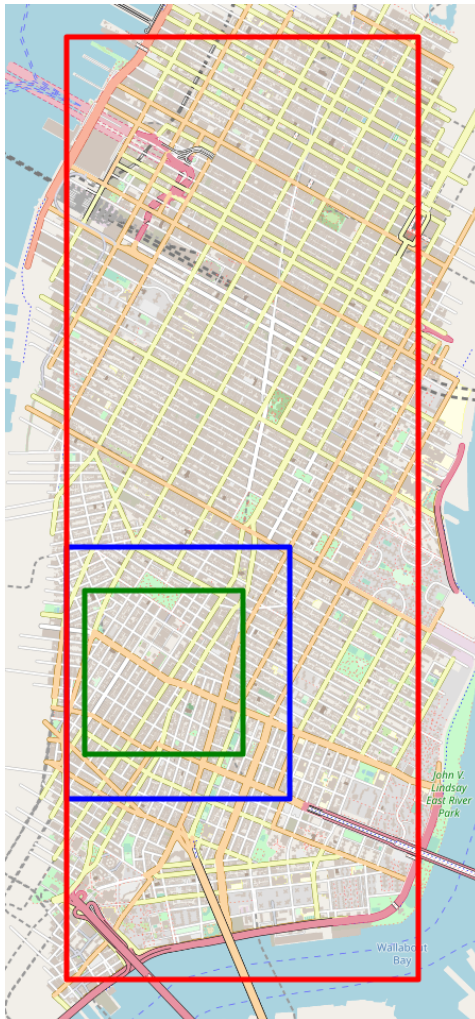Paper under double-blind review

Appendices

A   Dataset Split

Figure 1: Dataset splits: All 700 routes that are exclusively in the green rectangle are in the unseen test set. All 605 routes that cross the green border are in the development set. None of those development set routes extend further than the blue rectangle. The training set consists of routes within the red rectangle but outside of the green rectangle. The partially seen test set consists of 700 randomly sampled routes from the training set (and removed from the training set). Partially seen means that subsequences of those routes can be present in the training set.

B   Data Collection Navigation Run Analysis

Reason	failed navigation runs		Description
	invalid	valid	
bad instruction:			the instructions are the reason for a failed navigation run
turning direction	11	1	mix up left and right at an intersection; too vague (e.g. sharp left)
POI orientation	1	1	mix up left and right hand side for a point of interest
light/intersection	1	0	refer to lights when there is a plain intersection
intersection count	6	0	e.g. writes to turn after two intersections when there are three
mixed start and goal	2	0	instructions describe the route from goal location to start location
not visible POI	2	0	POI is not identifiable in Street View (e.g. New York Film Academy)
overpass/tunnel	1	0	mistake tunnel or overpass as intersection
bad run:			the navigation run annotator made a mistake during the run
turning direction	0	1	turns into the incorrect direction at an intersection
intersection count	8	9	turns an intersection too early or too late; ambiguous double intersection
stopped early	0	4	stopped the run without noticeable reason; technical reason or distracted
missed POI	1	5	did not see POI despite it being visible
data:			run fails because of mismatch in the data of OSM and Street View
blocked view	2	3	view blocked by e.g. vehicle or construction scaffolding
missing POI	8	3	point of interest is preset in OSM, but not in Street View
POI wrong location	3	3	POI is in a slightly different location (one/two buildings off)
Street View graph	1	2	white arrows are overlapping or image does not match the location

Table 1: Reasons for failed navigation runs. Analysis for two sets of 50 runs each. First set are failed runs for instructions that where not validated (first try and second try failed). The other set are failed first try runs for instructions that were validated (second try passed).

In Table 1 we present results from manually analyzing and categorizing reasons for failed navigation runs. The runs stem either from instructions that were not validated (first try and second try failed) or from instructions that were validated (second try passed). The data shows that the navigation runs are a good tool to filter out incorrect instructions. Only two of the examined instructions got validated despite containing incorrect statements. In the case of wrong turning direction, the instruction was not clear about how sharp the next left turn will be. The annotators in the navigation run interpreted it different, leading to a failed and a passed run. The most common mistake in navigation runs is incorrect assessment of when to turn at an intersection. Often this happens after double intersections that are referred to as two intersections from the map perspective but appear to blend into one in Street View. Sometimes runs end abrupt with no identifiable reason, probably due to technical issues (e.g. slow internet). We saw those usually during the beginning of the data collection and assume annotators were able to fix the issue or simple stopped working on our task. The probability for this to happen to two different annotators in the first and second try is very low and as such is not a reason for failed runs of invalidated instructions. Some runs failed not due to human errors but inconsistencies in the data. OSM annotation errors result in missing or misplaced POIs. For the remaining failed runs no clear reason could be identified.

C   Evaluation Navigation Success Rate Analysis

We analyze the navigation success rate in respect to properties of the corresponding routes. Figure 2 shows that the length of the route has little influence on the navigation success rate on the partially seen test set. On the unseen data there is tendency in favor of shorter routes for the g2t+pretrain model. The reference instructions do not show such bias. In contrast to pure length, the number of intersections are a better indicator for route complexity and are plotted in Figure 3. The navigation success of the g2t+pretrain model on the 700 instances test sets clearly drops with increasing number of intersections. Again the reference instructions show equal performance across all numbers of intersections. Figure 4 shows navigation success in respect to number of turns in a route which is another complexity indicator. The success rate drops with an increasing number of turns for all systems but not for the reference instructions. The analysis reveals that performance of our model drops with increasing route complexity while it is stable for reference instructions. The rule based system appears to be more stable with increasing number of intersections and turns in comparison to the learned models.
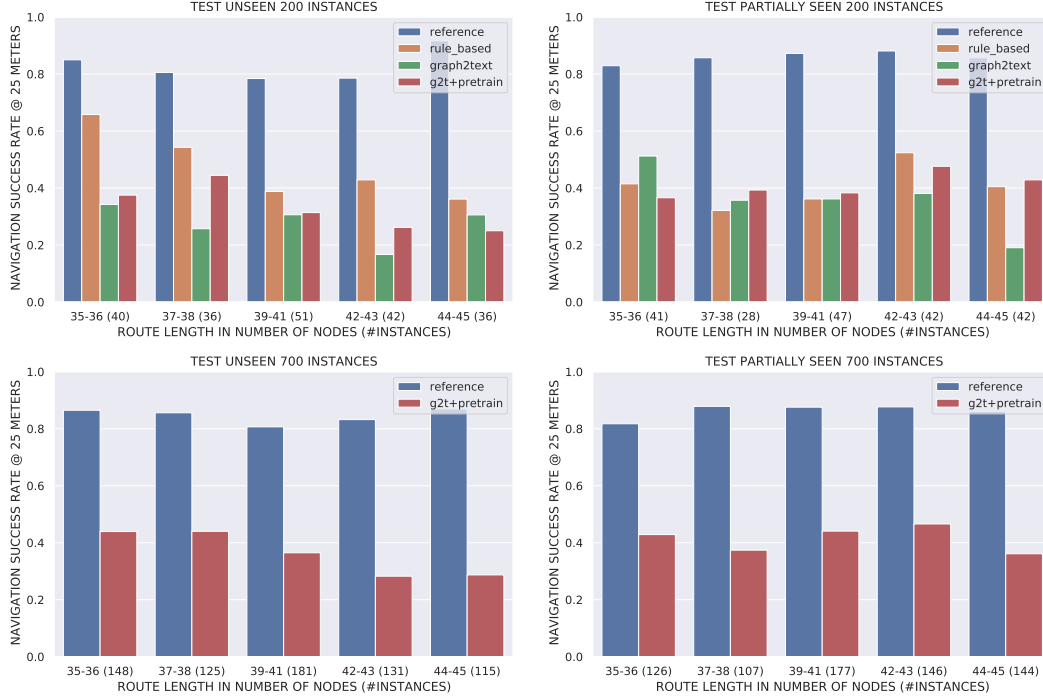
Figure 2: Analysis of navigation success rate in respect to route length. Length is measured in number of nodes in a route.
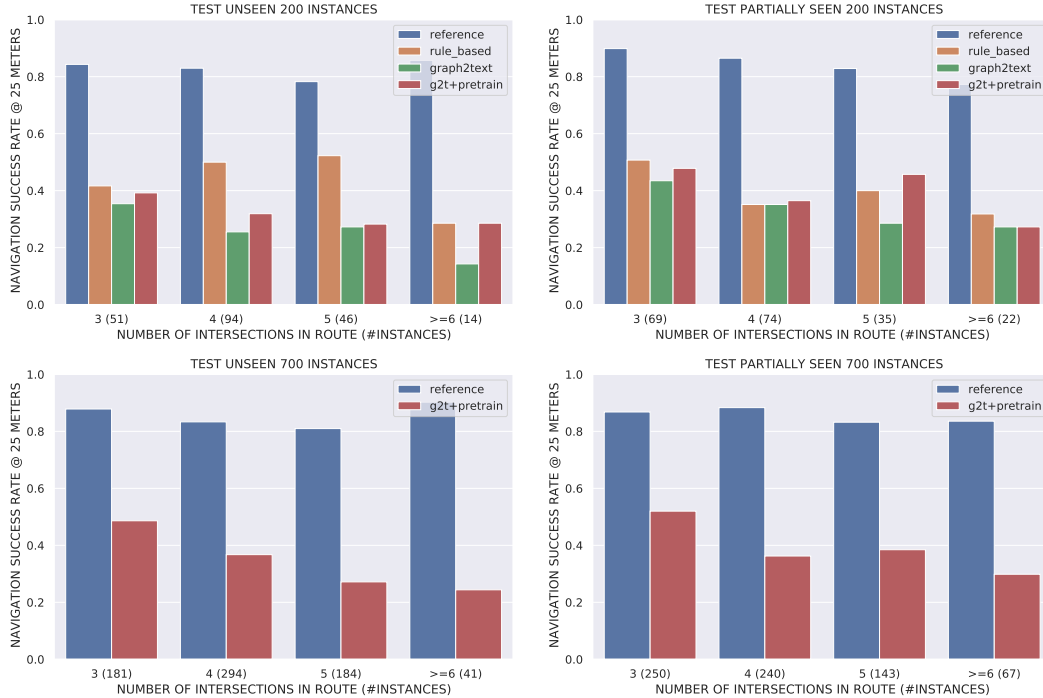

Figure 3: Analysis of navigation success rate in respect to number of intersections in a route. Each node in the route with more than two neighbors is counted as an intersection.
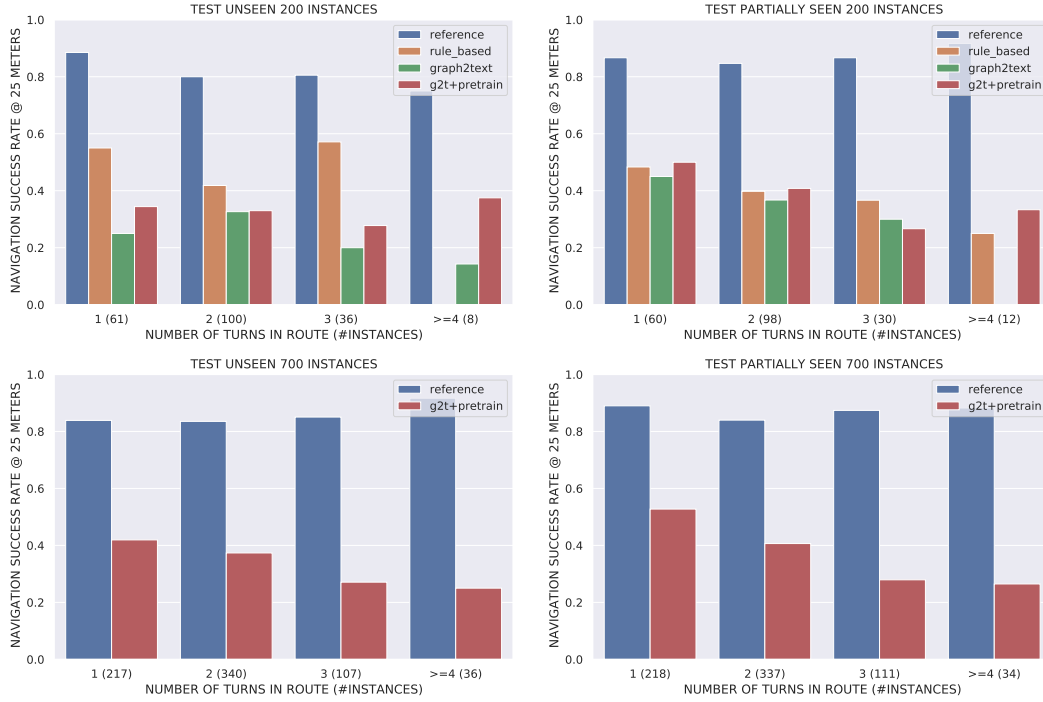
Figure 4: Analysis of navigation success rate in respect to number of turns in a route. A turn is defined as an intersection that the route isn't crossing in a straight angle. The straight angle is between 345°and 15°.
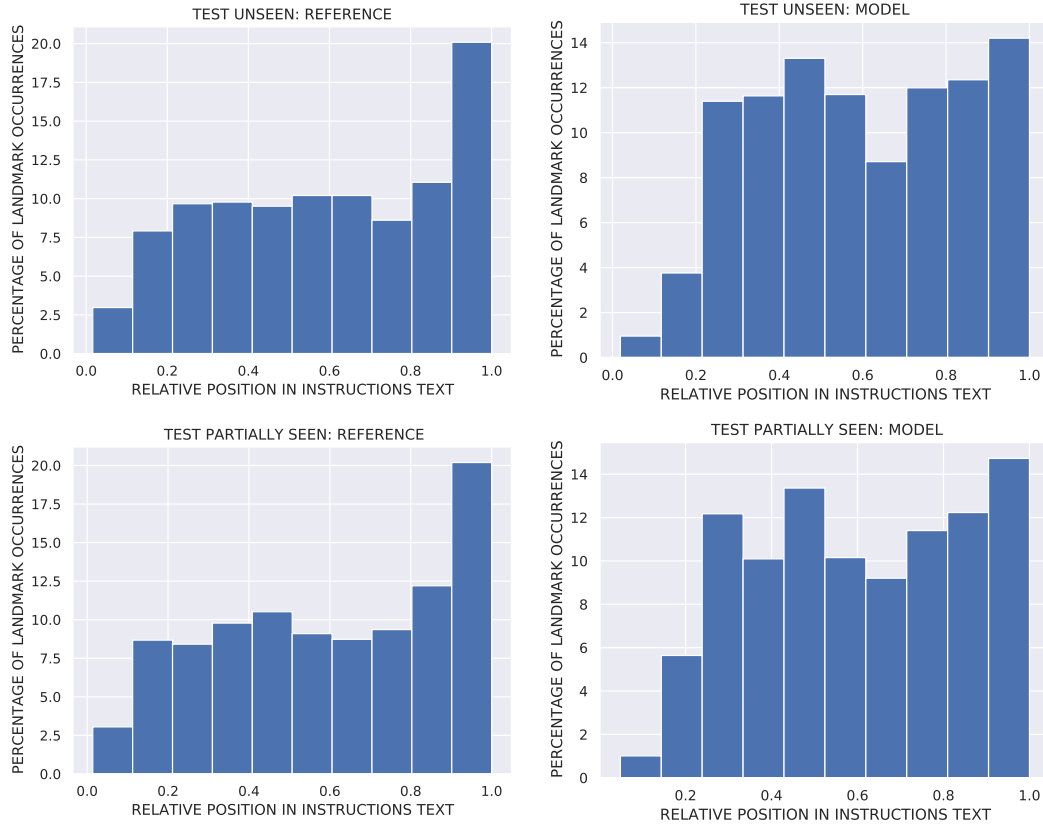
D   LANDMARKS

Figure 5: Relative position of landmark occurrences in the navigation instructions produced by humans and system, on the partially seen and unseen test set.

Figure 5 shows the relative position of landmarks in 10% bins of navigation instructions. On both unseen and partially seen human-generated test instances, the majority of landmarks is found in the last 10% of the instruction sequence. In the model-generated instructions the distribution is more even but also shows less landmarks in the beginning than the end of the text.

E   EXAMPLES
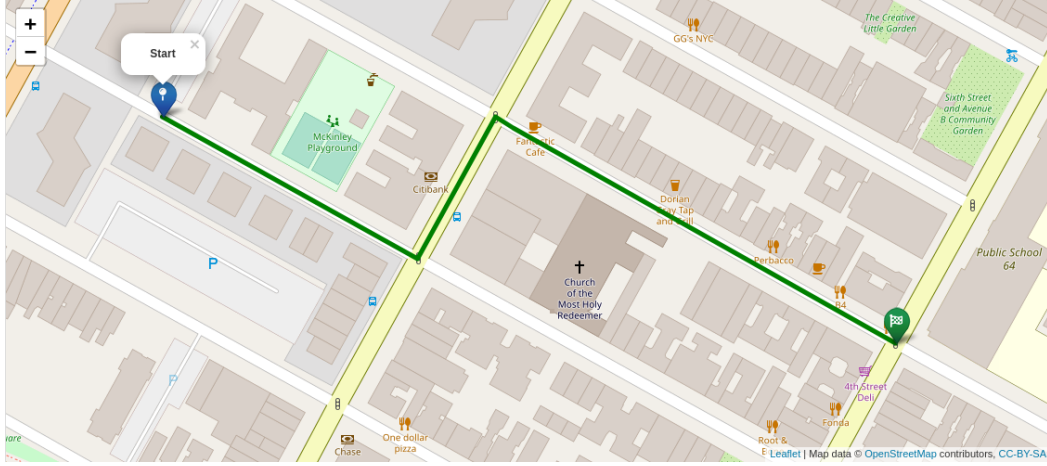
reference: *Head straight past the playground and turn left at the light. Turn right at the next light with Fantastic Cafe on the right. Continue down the very long street and stop at the next light with turntable 5060 on the near left corner.*
rule based: *parking left pitch left playground left pitch left bus stop right light left light right Fantastic Cafe left Church of the right Dorian Gray Tap left Perbacco left Matcha Cafe Wabi left B4 left stop*
seq2seq: *Go straight to the light and turn left. Go straight to the first light and turn left. Go straight to the first light and stop a couple of steps before the next light. You should see Perbacco on your left.*
graph2text: *Head to the light and turn left. At the next light with Fantastic cafe on your near right corner, turn right. Go to the next light and stop in the middle of the intersection. B4 Gray Tap should be on your left.*
g2t+pretrain: *Head to the light and turn left. At the following light with Fantastic cafe on the far left corner, turn right. Go to the next light with 4th street Deli on the near left corner and stop in the middle of the intersection.*
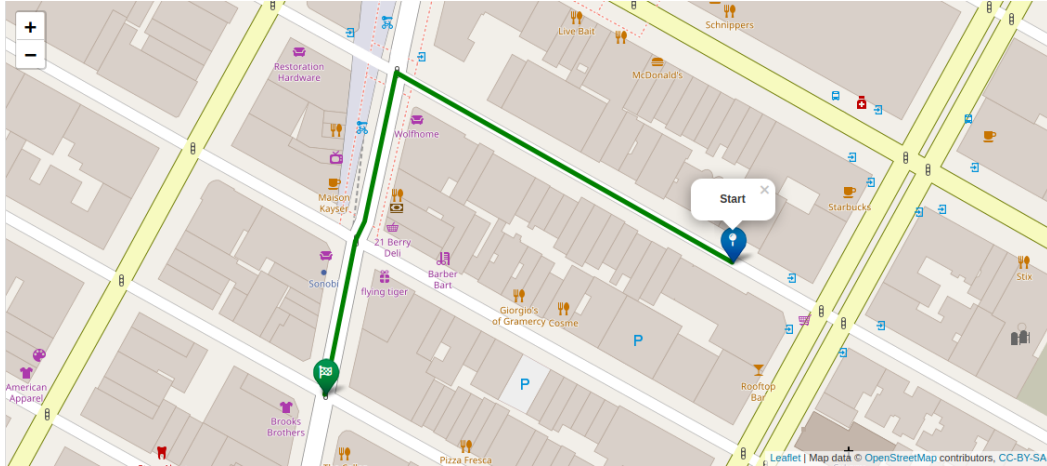
reference: *Continue down the long block and turn left at the light, Wolfhome on the corner. Pass Valley National Bank on the left, and go through the light, Ethan Allen on the far corner. Stop in the intersection of the following light, Brooks Brothers on the far corner.*
**rule based:** *Wolfhome left subway entrance right light left bicycle repair station right Citi Bike right Le Pain Quotidien right Bang & Olufsen right Maison Kayser right Obica Mozzarella Bar left Valley National Bank left 21 Berry Deli left light straight flying tiger left Ethan Allen right stop*
seq2seq: *Go straight to the light and turn right. Go straight to the first light and turn right. Go straight through the first light and stop a couple of steps before the next light. Ethan Allen should be on your right.*
graph2text: *Head to the light and turn left. Go past the 1st light with Ethan Allen on the left corner. At the 2nd light with Brooks Brothers on the near right corner, stop in the intersection.*
g2t+pretrain: *Head to the light and turn left. Go past the 1st light with Ethan Allen on the left corner. At the 2nd light with Brooks Brothers on the far right corner, stop in the intersection.*

Figure 6: Routes from partially seen test set with successful navigation for g2t+pretrain.
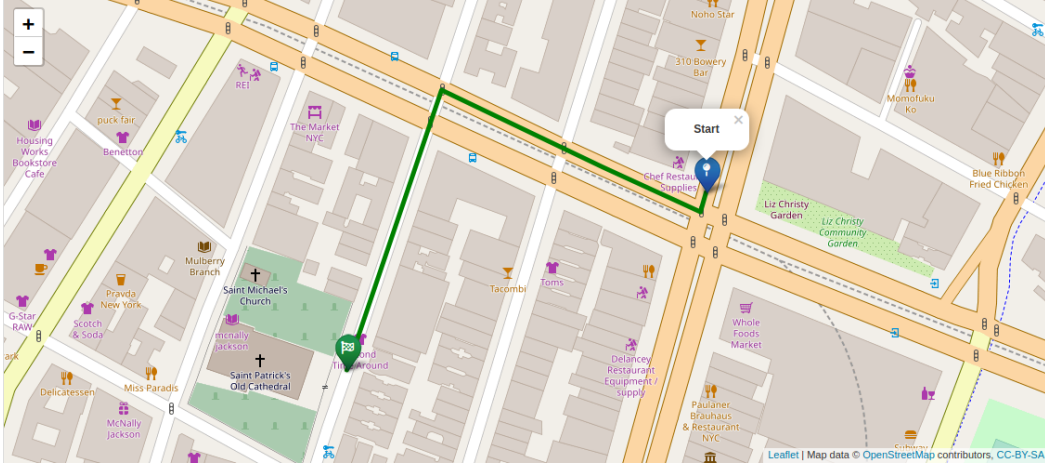
reference: *Turn right at the light right ahead of you. Go through the following light. The next light is a double intersection. Turn left at the first of the lights, and go through the second one. Pass a graveyard on the right and stop at the end of it, right as the church starts. It's about 2/3 down the block.*

rule based: *Garden left light right Chef Restaurant Supplies right light straight bus stop left light left light straight grave yard right stop Saint Patrick's right*

seq2seq: *Go to the light and turn right. Go through the following light, Restaurant on the corner. Pass a bus stop on the right, and go through the light. At the following light, bus stop on the corner, turn left. Go through the following light, and stop after a step or two. Saint Mary's church will be on the right.*

graph2text: *Turn right at the first set of lights. Go through the next set of lights and then turn left at the following lights. Pass Second Time Around half way down the block. Stop at Saint's around Saint's church on the right.*

g2t+pretrain: *Go to the light and turn right. Go straight through 1 light and at the following light, there should be a bus stop on the far left corner. Turn left and go about 1/2 to the next light, stopping in front of Saint Patrick's church on the right and graveyard Memorial's on the right.*
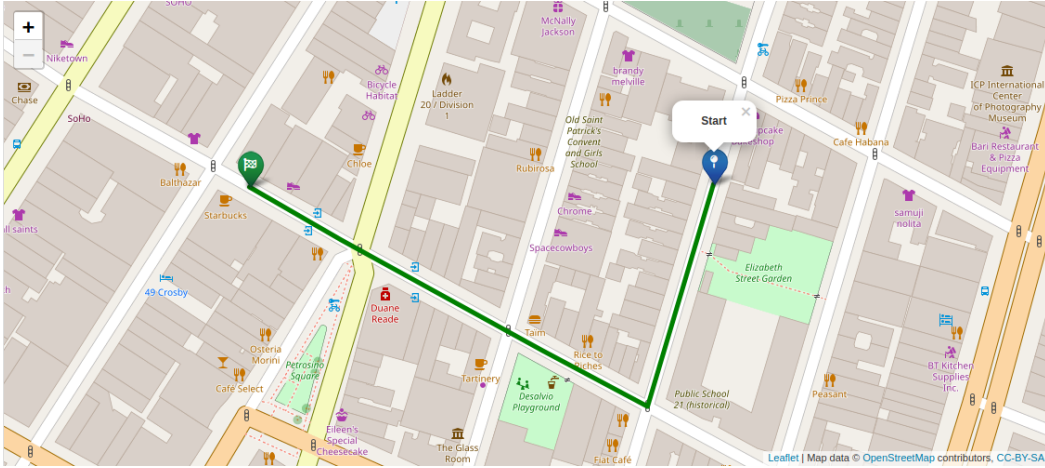
reference: *Head to the intersection and turn right. Continue straight past the next 2 intersections where there is a Duane Reade on your left. Go about 3/4 way down the block and stop right when you get to Starbucks on left.*

rule based: *Park left Public School 21 left light right Lombardi's Pizza left park left Rice to Riches right drinking water left playground left Taïm right light straight Tartinery left Duane Reade left light straight restaurant left Premium Laces right Starbucks left stop*

seq2seq: *Head to the light and turn left. Go past the 1st light with Duane Reade on the left corner. Go past the 2nd light with Duane Reade on the left corner. At the 3rd light with Starbucks on the far left corner, stop in the intersection.*

graph2text: *Head to the light and turn right. Go past the next 2 lights with Duane Reade on the far left corner. Go 1/2 block and stop one step before reaching the next light. Starbucks should be on your left.*

g2t+pretrain: *Head to the light and turn right. Go past the 1st light with Duane Reade on left corner. Go past the 2nd light with Duane Reade on the left corner. Go almost all the way down the block and stop one step before reaching the next light. Starbucks should be on your left.*

Figure 7: Routes from unseen test set with successful navigation for g2t+pretrain.

reference: *Go to the light and turn right. Go through the following light with Optical 88. The next light will have Da Gennaro on the far right corner, go through the light. Go through the following light as well, with a school on the corner. Turn right at the following light. Take the first left possible and stop after a few steps.*

rule based: *Hong Kong Supermarket left light right Sweet Moment left light straight 12 Corners right light straight Da Gennaro right Public School 130 right light straight parking left May Wah Vegetarian right Hair Lounge right light right intersection left stop*

seq2seq: *Go straight and take a right at the intersection where Hong Kong supermarket is. Go through the next three intersections and at the fourth one take a right and stop at Hair Lounge.*

graph2text: *Go to the light and turn right. Go through the following light, Optical 88 on the corner. Go through the following light as well, Da Gennaro on the corner. At the following light, Hair Lounge on the corner, turn right. Take a step and stop.*

g2t+pretrain: *Head to the light and turn right. Go past the next 2 lights with Da Gennaro on the right corner. At the 3rd light with May Wah Vegetarian on the far right corner, turn left. Take one step and stop.*
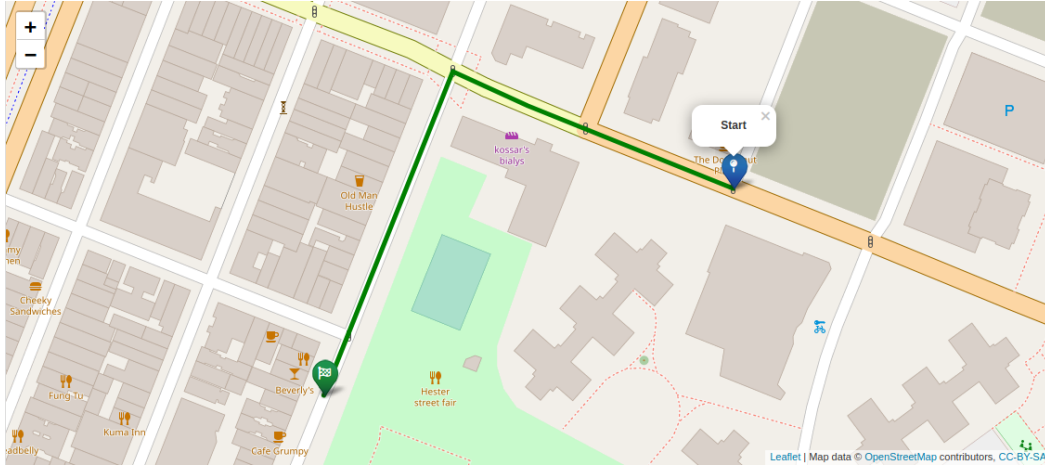
reference: *Go straight through one light. Pass kossar's bialys on the left before turning left at the next light. You'll go straight through one more light after that, with the park on your left. Stop in front of the building right after Beverly's on the right. If you don't see Beverly's, it's right after Sam's Spring Roles.*

rule based: *light straight The Doughnut Plant right light straight kossar 's bialys left light left park left Old Man Hustle right pitch left light straight Sam 's Spring right Beverly 's right stop*

seq2seq: *Go straight through 2 traffic lights and at the following light, there should be a park or park on the far left corner. Turn left and go straight through 1 light and stop 1/2 to the next light, adjacent to Sam's Beverly's on the right side.*

graph2text: *Go straight through the first intersection and at the second one take a left. Go through the next intersection and stop at Beverly's.*

g2t+pretrain: *Go to the second set of lights and turn left. Pass kossar man on the left and go through the lights. Pass Beverly's bialys on the right and go through the lights. Pass Beverly's on the left and go through the lights. Stop just after passing Beverly's on the right.*

Figure 8: Routes from partially seen test set with unsuccessful navigation for g2t+pretrain.
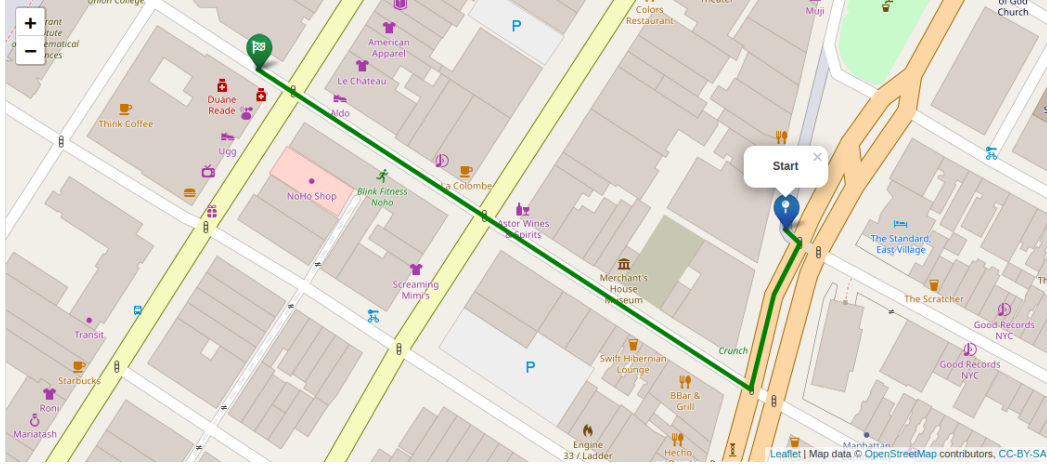
reference: *Go straight to the light and turn right. Go through the next 3 lights. At the 4th, there is a Chase and Nike store on the corners. Go through the intersection and stop on the other side at your destination.*

rule based: *Public School 21 left light right Lombardi's Pizza left park left Rice to Riches right drinking water left playground left Taïm right light straight Tartinery left Duane Reade left light straight restaurant left Premium Laces right Starbucks left light straight MUJI at MoMA right Balthazar left SoHo left light straight Niketown right stop Chase left Chase left shelter left*

seq2seq: *Head to the light and turn right. Go past the next 3 lights with Starbucks on the left corner. At the 4th light with Chase bank on the near left corner, cross the street and stop.*

graph2text: *Head to the light and turn right. Go past the next 2 lights with Starbucks on the far left corner. At the 3rd light with Chase on the far left corner, cross the street and stop. Chase should be on your left.*

g2t+pretrain: *Head to the light and turn right. Go past the next 3 lights with Starbucks on the left corner. At the 4th light with Chase on the near left corner, cross the street. Take one step and stop.*

reference: *Turn right at the first light in the double intersection ahead and head to the next light. Crunch might be on your near right corner. Turn right. Now go straight through two lights. Aldo should be near the right near corner. Go straight through this intersection and stop before Duane Reade.*

rule based: *Light right sports centre right light right BBar & Grill left Swift Hibernian Lounge left Merchant's House right Astor Wines & right light straight La Colombe right Other Music right fitness centre left French Connection right Aldo right Le Chateau right NoHo Shop left light straight Bath & Body left Duane Reade left stop*

seq2seq: *Head to the light and turn right. Go past the 1st light with Merchant's on the right corner. At the 2nd light with Duane Reade on the near right corner, cross the street and stop.*

graph2text: *Turn right at the first set of lights. Pass Merchant's on the right and turn right at the lights. Go through the next two sets of lights. Pass Duane Reade on the left and stop at Duane Reade on the left.*

g2t+pretrain: *Turn right at the light directly in front of you. At the next light with Panorama Will be on the right corner, turn right. Go past the next 2 lights with La Colombe on the right corner. At the 3rd light with Duane Reade on the near left corner, cross the street, then stop.*

Figure 9: Routes from unseen test set with unsuccessful navigation for g2t+pretrain.