SMART CITY MODELING: USING GIS CAPABILITIES TO SIMULATE URBAN AREAS AND EVENTS

<u>Topic</u>	Data to be analyzed	What data is produced?	How can the data be used?	
Transportation Monitoring optimal routes		Fastest route of the least miles and time required	Provide estimations on time of travel	
	Road congestions	Number of vehicles at a given location	Provide areas of congestion to be optimized or reorganized	
	Road construction and accident sites	Efficiency of travel of alternate paths of travel	Provide alternate routes to possible road closures	
	Public transportation efficiency	Efficiency of travel Areas of use Cost of use	Provide the efficiency of public transportation in a large or small scale	
	Snow or emergency routes	Efficiency of a given route, response time	Provides the city the means to plan smarter routes for response teams for emergencies or weather conditions	
	Alternate means of travel	Cost of use/upkeep Areas of use Efficiency of travel Percentage used by population	Provide the efficiency and feasibility of alternate means of travel	
Pedestrian	Safety of urban environment	Track areas of crime and closed off areas	Find and reduce areas of crime to make them more safe for pedestrians, or track change of pedestrian flow due to closed off areas	
	Walkability of urban environment	Sidewalk layout efficiency	Is a "15-minute city" achievable in the given area? Provide information on what can be changed to achieve this goal.	
	Accessibility of amenities	Time or distance from a given location required for living	Provide information of distance of amenities like stores, work, education, or housing	
	Accessibility of public transportation	Distance from a bus route/assembly or a subway station entry	Provide optimal locations for public transportation with high areas of use	
	Accessibility of nightlife	Lighting feasibility Number of places of interest or amenities for nightlife	Provide the number of street lights needed for nightlife Provide information of open or closed amenities for nightlife	

Infrastructure	Water and power supply	Amount of water and power supply used or needed	Provide the cost and amount required in a given location			
	Waste Management	Efficiency of waste collection and tracking the amount collected	Provide information of waste collection and its efficiency			
	Infrastructure placement	Efficiency and accessibility of infrastructure	Provide optimal locations of law enforcement, education, and healthcare for response times and accessibility			
Environment	Healthcare	Areas of disease spreading or high pedestrian count	Provide information of disease spreading and other health concerns			
	Air and water pollution	Areas of high pollutants and the causes	Provide information on the amount of pollution in an urban setting to find an efficient solution			
	Green Spaces	Amount of green spaces in a given urban environment	Provide information on whether more green spaces, such as parks or fields, are needed			

SPRING 2024

block_type	block	activity_type	mean (seconds)	total (seconds)	min (seconds)	max (seconds)	n_agents	mean (minutes)	total (minutes)	min (minutes)	max (minutes)
MoveTo	destination46NorthPints	MOVE	297.5417721	80931.362	100.687	738.711	270	0:04:58	22:28:51	0:01:41	0:12:19
MoveTo	destinationBarryHall	MOVE	420.9085148	113645.299	19.138	785.268	267	0:07:01	31:34:05	0:00:19	0:13:05
MoveTo	destinationBeerAndFishCompany	MOVE	289.120364	78640.739	4.465	707.876	271	0:04:49	21:50:41	0:00:04	0:11:48
MoveTo	destinationBernBaums	MOVE	318.4108971	77373.848	30.03	825.212	240	0:05:18	21:29:34	0:00:30	0:13:45
MoveTo	destinationBismarckTavern	MOVE	436.4889793	105630.333	35.763	957.324	236	0:07:16	29:20:30	0:00:36	0:15:57
MoveTo	destinationBlackBirdWoodFirePizza	MOVE	264.9847107	74195.719	17.512	801	276	0:04:25	20:36:36	0:00:18	0:13:21
MoveTo	destinationBlackCoffeeAndWaffleBar	MOVE	565.7107647	153873.328	8.716	1161.479	270	0:09:26	42:44:33	0:00:09	0:19:21
MoveTo	destinationBossPizzaAndChicken	MOVE	309.5659216	94727.172	6.751	719.05	303	0:05:10	26:18:47	0:00:07	0:11:59
MoveTo	destinationChubsPub	MOVE	796.4397574	216631.614	200.025	1186.227	271	0:13:16	60:10:32	0:03:20	0:19:46
MoveTo	destinationCowboyJacks	MOVE	379.8855667	102569.103	35.763	921.561	267	0:06:20	28:29:29	0:00:36	0:15:22
MoveTo	destinationDempseys	MOVE	275.6015285	72483.202	5.21	712.299	261	0:04:36	20:08:03	0:00:05	0:11:52
MoveTo	destinationDisctrict64	MOVE	346.5014167	83160.34	31.118	923.767	239	0:05:47	23:06:00	0:00:31	0:15:24
MoveTo	destinationDrunkenNoodle	MOVE	346.5342227	88712.761	3.508	857.422	253	0:05:47	24:38:33	0:00:04	0:14:17
MoveTo	destinationEmpireTavern	MOVE	340.02925	88407.605	1.422	874.166	260	0:05:40	24:33:28	0:00:01	0:14:34
MoveTo	destinationFargoCivicCenter	MOVE	418.129412	111640.553	199.94	1010.397	264	0:06:58	31:00:41	0:03:20	0:16:50
MoveTo	destinationFargoTheatre	MOVE	323.5175146	88643.799	17.139	768.1	270	0:05:24	24:37:24	0:00:17	0:12:48
MoveTo	destinationFirstLutheranChurch	MOVE	608.2205365	141715.385	9.531	1144.5	232	0:10:08	39:21:55	0:00:10	0:19:05
MoveTo	destinationFortNoks	MOVE	364.4290077	94751.542	13.663	1016.956	259	0:06:04	26:19:12	0:00:14	0:16:57
MoveTo	destinationHavocHouse	MOVE	295.9765394	75178.041	4.465	712.341	251	0:04:56	20:52:58	0:00:04	0:11:52
MoveTo	destinationKlaiHall	MOVE	372.168354	101974.129	40.57	682.674	269	0:06:12	28:19:34	0:00:41	0:11:23
MoveTo	destinationLittleBrother	MOVE	597.5844415	158359.877	0.598	1186.227	265	0:09:58	43:59:20	0:00:01	0:19:46
MoveTo	destinationMezzaluna	MOVE	297.9132992	75669.978	17.139	750.961	252	0:04:58	21:01:10	0:00:17	0:12:31
MoveTo	destinationNoBullSmokehouse	MOVE	362.2146846	101057.897	19.815	979.267	277	0:06:02	28:04:18	0:00:20	0:16:19
MoveTo	destinationOldBroadway	MOVE	379.2595692	98607.488	13.684	1006.214	258	0:06:19	27:23:27	0:00:14	0:16:46
MoveTo	destinationParadoxEventCenter	MOVE	448.2753077	116551.58	112.201	838.899	259	0:07:28	32:22:32	0:01:52	0:13:59
MoveTo	destinationPhoDLicious	MOVE	387.1195986	113813.162	19.816	959.451	291	0:06:27	31:36:53	0:00:20	0:15:59
MoveTo	destinationPixeledBrewing	MOVE	637.0976681	145895.366	15.12	1088.997	229	0:10:37	40:31:35	0:00:15	0:18:09
MoveTo	destinationPlainsArtMuseum	MOVE	368.0887796	90181.751	91.76	772.193	242	0:06:08	25:03:02	0:01:32	0:12:52
MoveTo	destinationPokeBowl	MOVE	590.9709158	168426.711	8.716	1170.196	284	0:09:51	46:47:07	0:00:09	0:19:30
MoveTo	destinationPounds	MOVE	434.2408962	112902.633	12.395	1084.935	259	0:07:14	31:21:43	0:00:12	0:18:05
MoveTo	destinationProofArtisanDistillers	MOVE	288.7442459	70453.596	16.717	766.77	242	0:04:49	19:34:14	0:00:17	0:12:47
MoveTo	destinationRenaissanceHall	MOVE	416.4233745	104522.267	123.741	888.286	250	0:06:56	29:02:02	0:02:04	0:14:48
MoveTo	destinationRootersBar	MOVE	292.3111786	73662.417	59.215	885.111	250	0:04:52	20:27:42	0:00:59	0:14:45
MoveTo	destinationRoughCutSocial	MOVE	611.5793295	161456.943	15.12	1073.877	260	0:10:12	44:50:57	0:00:15	0:17:54
MoveTo	destinationSanctuaryEventsCenter	MOVE	379.5882069	99072.522	172.452	711.813	256	0:06:20	27:31:13	0:02:52	0:11:52
MoveTo	destinationSidestreetBarAndGrill	MOVE	396.4210579	102673.054	8.608	964.972	256	0:06:36	28:31:13	0:00:09	0:16:05
MoveTo	destinationSonsOfNorway	MOVE	385.5069756	94834.716	19.83	723.243	246	0:06:26	26:20:35	0:00:20	0:12:03
MoveTo	destinationSpicyPie	MOVE	314.5451978	87443.565	30.03	828.389	275	0:05:15	24:17:24	0:00:30	0:13:48
MoveTo	destinationSportsBar	MOVE	330.4140696	75995.236	31.118	906.355	229	0:05:30	21:06:35	0:00:31	0:15:06
MoveTo	destinationStoneEventCenter	MOVE	294.6526708	71600.599	38.836	838.576	241	0:04:55	19:53:21	0:00:39	0:13:59
MoveTo	destinationTacoShop	MOVE	581.8738444	149541.578	12.492	1186.227	256	0:09:42	41:32:22	0:00:12	0:19:46
MoveTo	destinationTeddysEateryAndParlor	MOVE	290.1278594	72241.837	16.717	783.487	247	0:04:50	20:04:02	0:00:17	0:13:03
MoveTo	destinationTheBoilerRoom	MOVE	283.4964484	79662.502	38.309	750.651	279	0:04:43	22:07:43	0:00:38	0:12:31
MoveTo	destinationTheFourAndFour	MOVE	420.4683425	106798.959	8.608	973.581	251	0:07:00	29:39:59	0:00:09	0:16:14
MoveTo	destinationTheNorthernGentlemansClub	MOVE	490.4702878	132917.448	38.77	863.799	268	0:08:10	36:55:17	0:00:39	0:14:24
MoveTo	destinationTheToastedFrog	MOVE	289.5797333	73842.832	9.331	787.939	252	0:04:50	20:30:43	0:00:09	0:13:08
MoveTo	destinationVFW	MOVE	258.8772448	62389.416	15.685	798.051	239	0:04:19	17:19:49	0:00:16	0:13:18
MoveTo	destinationVinyITaco	MOVE	318.9891227	88359.987	59.215	944.327	275	0:05:19	24:32:40	0:00:59	0:15:44
MoveTo	destinationWildTerraCider	MOVE	660.7049813	177068.935	78.943	1144.5	266	0:11:01	49:11:09	0:01:19	0:19:05
MoveTo	destinationWurstBierHall	MOVE	337.6336757	87447.122	38.835	877.41	254	0:05:38	24:17:27	0:00:39	0:14:37

Possible urban scenarios to simulate (blue inidicates the scenarios heavily studied).

This research aims to show the capabilities of smart city modeling using GIS and other accessible information to provide accuracy and precision. Through this data collection, architects and urban planners can strategically alter urban areas to promote user experience and contentment. Current well-established cities can become known as smart cities, or cities that are data driven. This collection of data, such as traffic data, can be used to improve the user experience through efficiency and correct implementation. The idea of a "walkable city" is also reinforced as an important design solution that directly impacts the user experience in this urban environment. Through this technology, architects and urban planners may use this workflow in future design projects that focuses on user experience and engagement.

Example chart of possible data produced through urban simulations.



This exploration aims to provide possible simulation methods for current smart city implementations and improvements. The impact of this project is to find if computational simulations and modeling can improve the overall health and well-being of users in an urban environment. The area of focus in the downtown urban setting of Fargo, North Dakota. Key aspects of this research include generative modeling and simulation of traffic flows on roads, pathways, alleys, and sidewalks.

D view of project location.

BACKGROUND





Figure-ground map highlighting buildings, green spaces, and primary and secondary roads.



Detailed map with street information and key points of interest.

LOCATION



In AnyLogic, blocks are used to define where the pedestrian starts, moves, waits, and stays. The Source Block, for example, defines where the pedestrian begins in the simulation. They can start from a certain point of the map (building) or in a defined area (downtown area). In the Source Block, we can set parameters that define how the pedestrian acts or moves, such as arrival rate and speed. Altogether, these blocks can be connected to simulate pedestrian movement. Additional coding is used to simulate pedestrian movement to the nearest destination.



Walkability of Urban Environment		Alternate Means of Travel (Car)		Alternate Means of Travel (Bike)				
	Downtown University		Travel by Car		Travel by Bike			
	•>•• 🕑 ••	0.00333333333 ~	Downtown University		Downtown University			
	Downtown Gas Station		•>• 🕑 •(X)	0.00333333333 ~	•>• •• •	0.00333333333 ~		
	+>>+> ⊙(×)	0.00333333333 ~	Downtown Gas Station		Downtown Gas Station			
	Downtown Green Spaces		↔ (b) ↔ (x)	0.00333333333 ~	+> • (b)•(X)	0.003333333333 ~		
	•>• 🕒 •—•	0.00333333333 ~	Downtown Misc Commercial Private		Downtown Green Spaces			
	Downtown Misc Commercial	Private		0.003333333333 ~	•>•—-• • •	0.003333333333 ~		
	•>• 🕑 ••	0.00333333333 ~	Downtown Parking	0.00333333333 ~	Downtown Misc Commercial Private			
	Downtown Bus Stations				•>•——• 🕑 •——•X	0.00333333333 ~		
	•>• 🕒 •—•	0.00333333333 ~	Downtown Hotels	0.00333333333 ~	Downtown Bike Parking			
	Downtown Bike Parking				•>•• 🕑 ••×	0.003333333333 ~		



Downtown Parking



Downtown Hotels



Downtown Church

(Æ)

Downtown Stoplight Intersections

Downtown Restaurants and Bars

0.003333333333 ~

0.003333333333 ~

0.003333333333 ~

0.003333333333 ~

0.003333333333 ~

0.003333333333 ~

Downtown Apartments



0.003333333333 ~

Downtown Misc Federal State



0.003333333333 ~

Downtown Misc Commercial Public



0.003333333333 ~

Downtown Church



Downtown Stoplight Intersections



Downtown Restaurants and Bars



Downtown Apartments



Downtown Misc Federal State

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Downtown Misc Commercial Public



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Downtown Hotels



0.003333333333 ~

Downtown Church



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Downtown Stoplight Intersections



0.003333333333 ~

Downtown Restaurants and Bars



0.003333333333 ~

Downtown Apartments



0.003333333333 ~

Downtown Misc Federal State



0.003333333333 ~

Downtown Misc Commercial Public



0.003333333333 ~







By examining multiple pedestrian simulations, the model during simulation exhibits plenty of movement in the downtown area. In addition, these studies were documented through a dataset that could recored the pedestrians' movement and travel distance. Through this data, diagrams can be created to dictate the walkabilty or efficiency of the urban area. In this case, downtown Fargo meets expectations of a walkable urban environment while also providing accessible alternate means of transportation.

Real world uses such as showing the distance to necessary or common building types are important to show the walkability of urban environments. While the models only simulate the downtown Fargo area, future models could perhaps simulate an entire city. This would result in a more advanced and accurate model.

GIS map of model in the process of simulation (black dots indicate moving pedestrians). Using GIS integration with AnyLogic provided accurate locations and distances which helped with overall organization and efficiency. However, new city designs can still use this workflow, but sidewalks, roads, and buildings would have to be modeled from the ground up.



Accessibility of Amenities in Downtown Fargo

Accessibility of Amenities in Downtown Fargo



Pedestrian — Average

Bike Travel in Downtown Fargo



Car Travel in Downtown Fargo



Foot Travel in Downtown Fargo



Foot Travel to a Bus Station in Downtown Fargo



RESULTS