

# GIScience in A Hybrid Physical-Virtual World

Shih-Lung Shaw

Chancellor's Professor & Alvin and Sally Beaman Professor  
Department of Geography and Sustainability  
University of Tennessee, Knoxville

&

President, University Consortium for Geographic Information Science (UCGIS)  
[sshaw@utk.edu](mailto:sshaw@utk.edu)

Texas A&M University  
February 27, 2023

# ChatGPT

ss Produce a presentation of GIScience in a hybrid physical-virtual world

Sure, here is a sample presentation of GIScience in a hybrid physical-virtual world:

Slide 1: Title slide  
Title: GIScience in a Hybrid Physical-Virtual World

Slide 2: Introduction

- Definition of a hybrid physical-virtual world
- Overview of GIScience

Slide 3: Key features of GIScience in a hybrid physical-virtual world

- Integration of physical and virtual data
- Use of 3D models, virtual reality, and geospatial analytics
- Enhanced visualization and analysis capabilities

Slide 4: Examples of GIScience in a hybrid physical-virtual world

- Tourism: use of virtual environments to enhance the visitor experience
- Disaster management: use of hybrid physical-virtual GIS to respond to natural disasters
- Transportation: use of real-time traffic data to optimize traffic flow

Slide 5: Theoretical foundations of a hybrid physical-virtual world

Regenerate response

[ChatGPT Feb 13 Version](#). Free Research Preview. Our goal is to make AI systems more natural and safe to interact with. Your feedback will help us improve.

# ChatGPT

ss What is a hybrid physical-virtual world?



A hybrid physical-virtual world refers to an environment that combines elements of both the physical and virtual worlds. This concept is often associated with the growing use of technology to create virtual experiences that interact with and complement physical experiences.

In a hybrid physical-virtual world, people can interact with each other, objects, and digital content in both physical and virtual spaces, seamlessly moving between the two. For example, a hybrid physical-virtual world could include augmented reality (AR) or virtual reality (VR) experiences that are layered onto physical environments, or digital platforms that allow people to interact with physical objects in real-time.

A hybrid physical-virtual world can also refer to the integration of physical and digital infrastructure in areas such as transportation, healthcare, and education. This could include things like virtual doctor's appointments, online learning, and smart cities that use technology to improve the functioning of physical infrastructure.

Overall, the concept of a hybrid physical-virtual world reflects the increasing integration of technology into our everyday lives and the blurring of the boundaries between the physical and virtual realms.

ss GIScience in a hybrid physical-virtu

# Two Major Limitations of Conventional GIS:

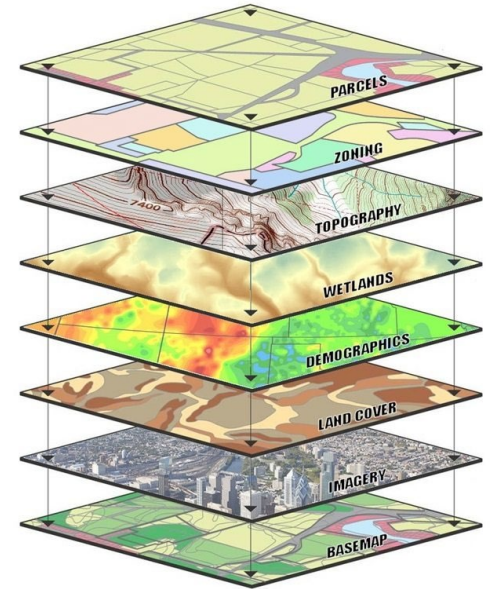
- Conventional geographic information systems (GIS) have been successfully employed in many studies that cover a wide range of disciplines and application domains.
- Two major limitations of conventional GIS:
  - 1) Conventional GIS have neglected **humans**, and
  - 2) Conventional GIS have focused mainly on **locations in physical space**.



# Conventional GIS:

- Conventional GIS follow the traditional cartographic approach of representing *locations* in *physical space* as *static* map layers.
- It is based on the *Newtonian absolute space* using *Euclidean geometry* and *Cartesian coordination system*.
- This conceptualization of space has major *limitations in today's world!*

## GIS Map Layers

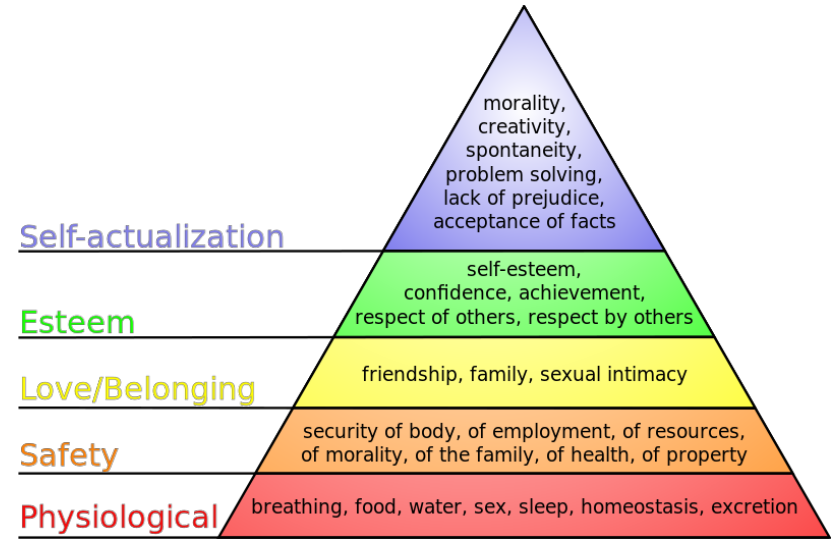


(<https://www.newbrightonmn.gov/departments/community-assets-development/geographic-information-systems-gis/>)

# Human Dynamics

# Human Dynamics:

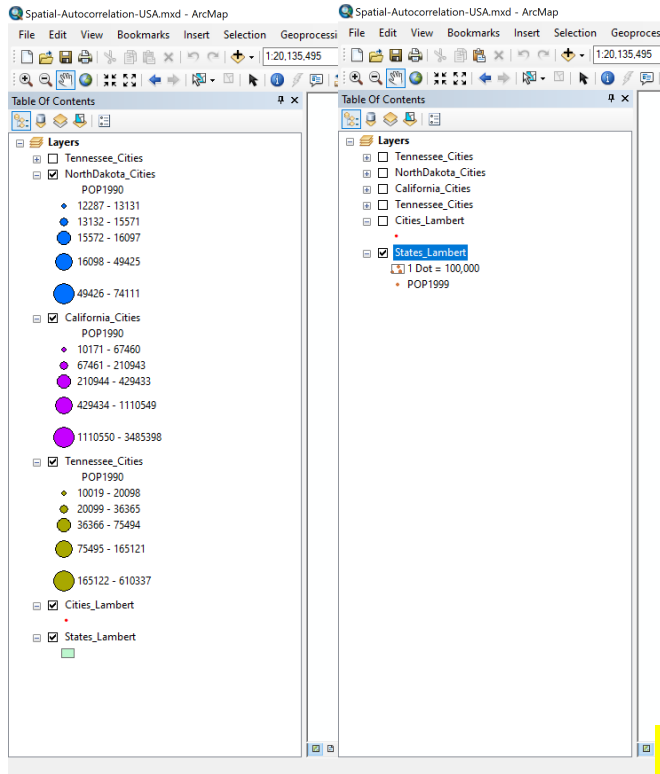
- Human beings have physiological, economical, social, and other needs that need to be fulfilled in our daily lives.
- **Human dynamics**, which refers to all types of human activities and interactions in both **physical and virtual** spaces, serves us to fulfill various human needs.



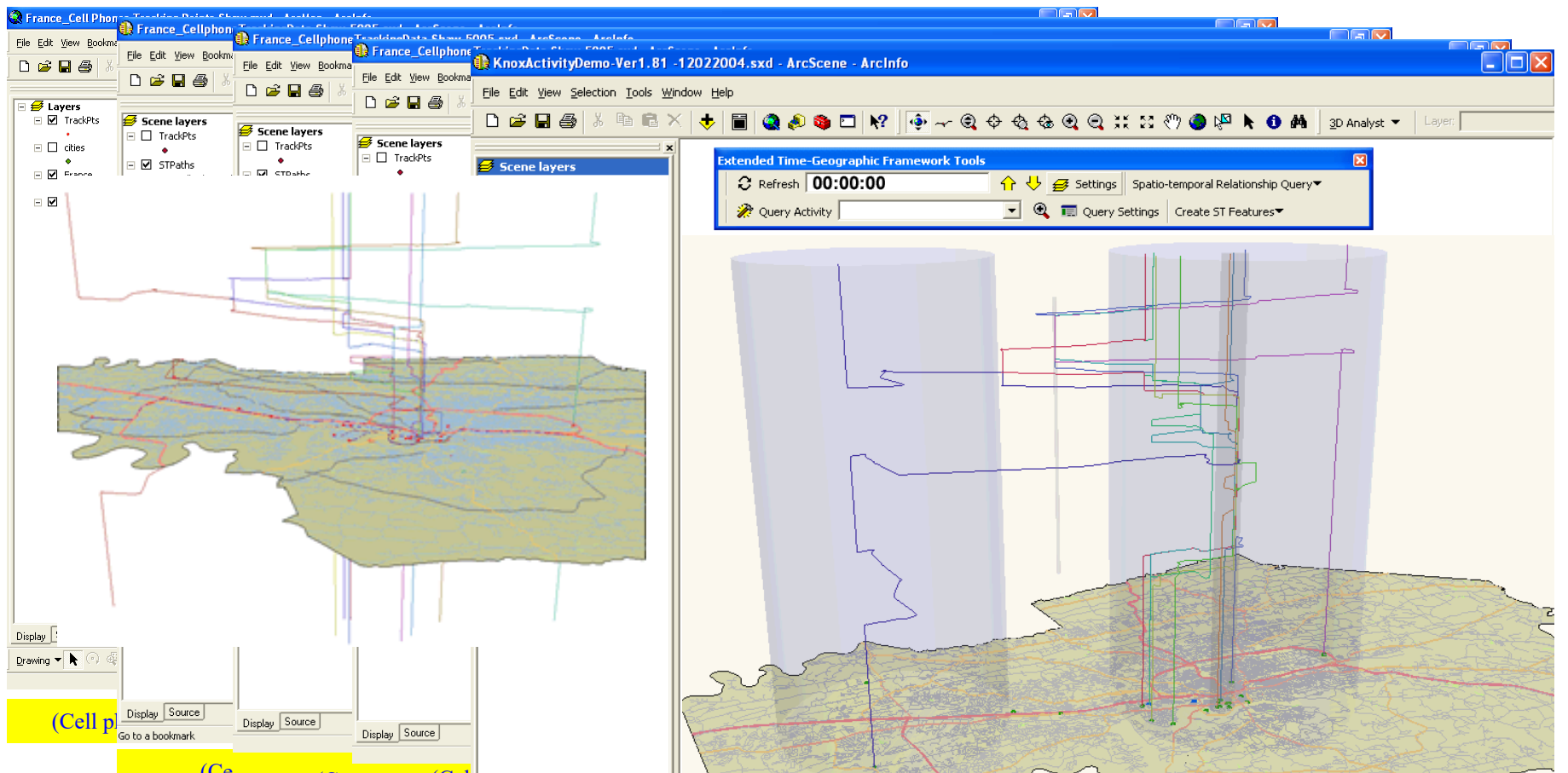
## Maslow's Hierarchy of Needs

[https://commons.wikimedia.org/wiki/File:Maslow%27s\\_hierarchy\\_of\\_needs.svg](https://commons.wikimedia.org/wiki/File:Maslow%27s_hierarchy_of_needs.svg)

# Humans in Conventional GIS:



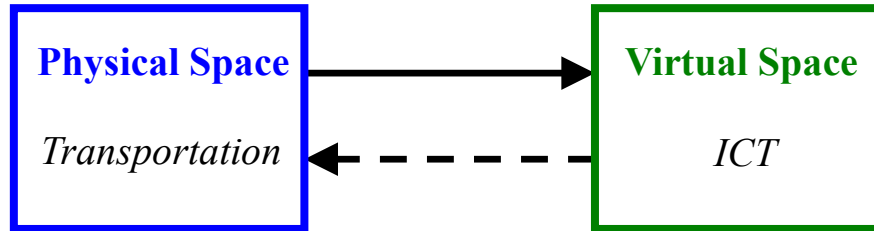
*Inter-city social interactions based on Tencent QQ social network data.*



See Yu & Shaw (2008), *IJGIS* and Shaw & Yu (2009), *Journal of Transport Geography*.

# A Hybrid Physical-Virtual World:

- Modern *information and communication technologies (ICT)*, such as the Internet and mobile devices, have significantly changed human dynamics in an increasingly *hybrid physical-virtual world*.
  - *Physical space* and *virtual space* interact with each other.
- Humans are *dynamic and living* entities!
  - We navigate in both physical and virtual spaces to carry out various activities and interactions in order to meet different needs.



# Different Forms of Hybrid Physical-Virtual World:

1. **Internet applications** such as Amazon, Google, Facebook (Meta), Tiktok, etc.
2. **Digital Twin**: A virtual model to accurately reflect a physical object or system and can be used to simulate the physical object/system.



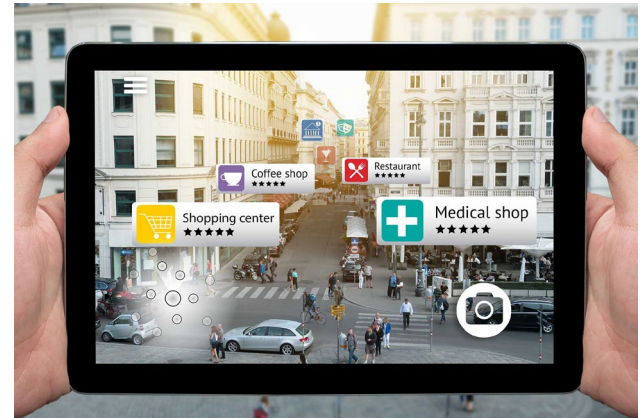


### 3. Augmented Reality (AR)/Virtual Reality (VR)/Extended Reality (XR) & Metaverse:

- AR is an interactive digital platform based on real-world objects that is enhanced by additional computer-generated information on top of the real-world objects.



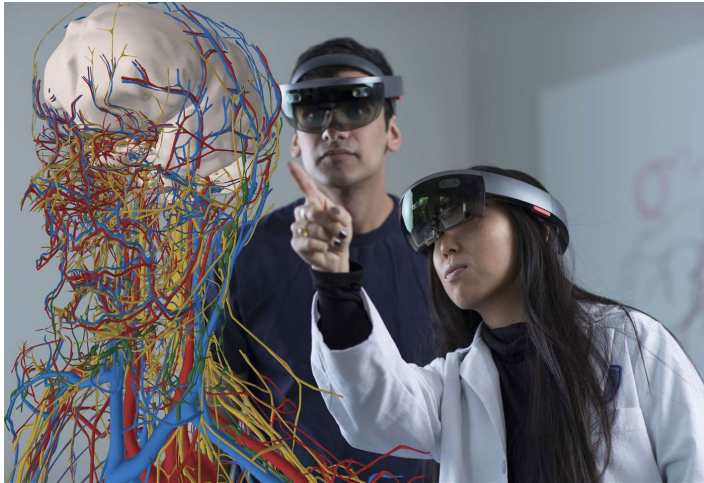
<https://geekdad.com/2016/07/pokemon-go-the-future-of-augmented-reality/>



<https://www.limecube.co/augmented-reality-explained>



- **VR** is an immersive and interactive digital environment to provide a simulated experience. Virtual space created by VR can emulate physical space in the real world or can create an imagined space.



<https://www.chronicle.com/article/virtual-reality-comes-to-the-classroom/>



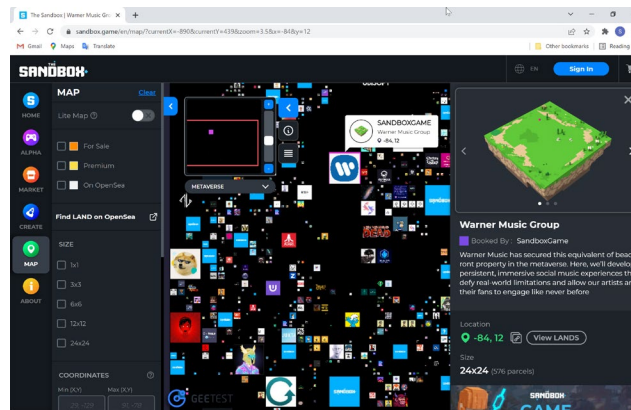
<https://news.asu.edu/20201222-creativity-exploring-new-worlds-virtual-reality>

- **Metaverse** can be understood as a future version of today's internet applications with a virtual world that is intertwined with the physical world with interactions between the two worlds.

#### 4. Other virtual forms such as phone calls, social relations, etc.



<https://www.forbes.com/sites/forbestechcouncil/2022/09/08/why-the-future-of-work-could-take-place-in-the-metaverse/?sh=46771c43bcf2>



<https://www.zdnet.com/article/best-telepresence-robot/>

- A hybrid physical-virtual world brings up new challenges:



- What is the “location” of Google (or Amazon, TikTok) in GIS?
- The location of Google could be represented by:
  - the coordinates of its headquarters in Mountain View, California, in absolute space,
  - the URLs of Google websites (e.g., [www.google.com](http://www.google.com) in the U.S, or [www.google.co.uk](http://www.google.co.uk) in the United Kingdom) in virtual space,
  - the Internet Protocol (IP) addresses of Google servers (e.g., 74.125.224.72), or
  - its identity as Google.



# Question:

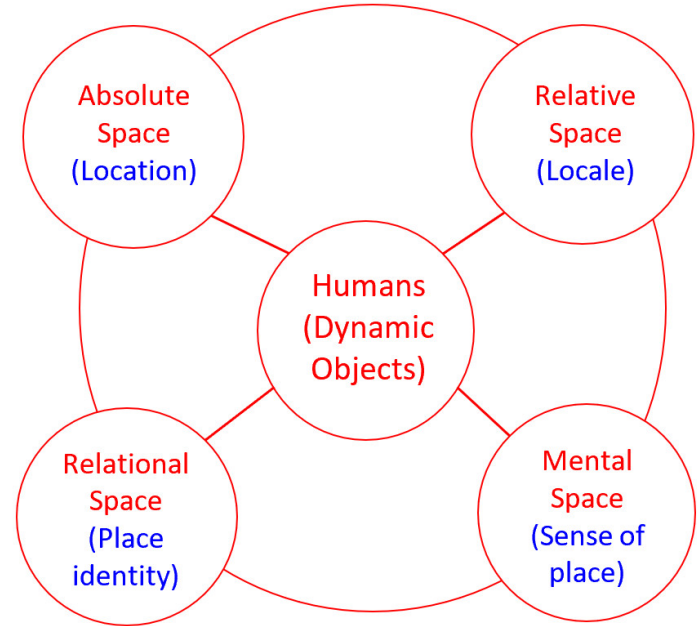
*Are GIS & GIScience ready for human dynamics in an increasingly hybrid physical-virtual world?*

# *A Space-Place GIScience Framework*

# A Space-Place (Splatial) GIScience Framework for Human Dynamics Research:

- Shaw and Sui (2020) propose a Space-Place GIScience framework.

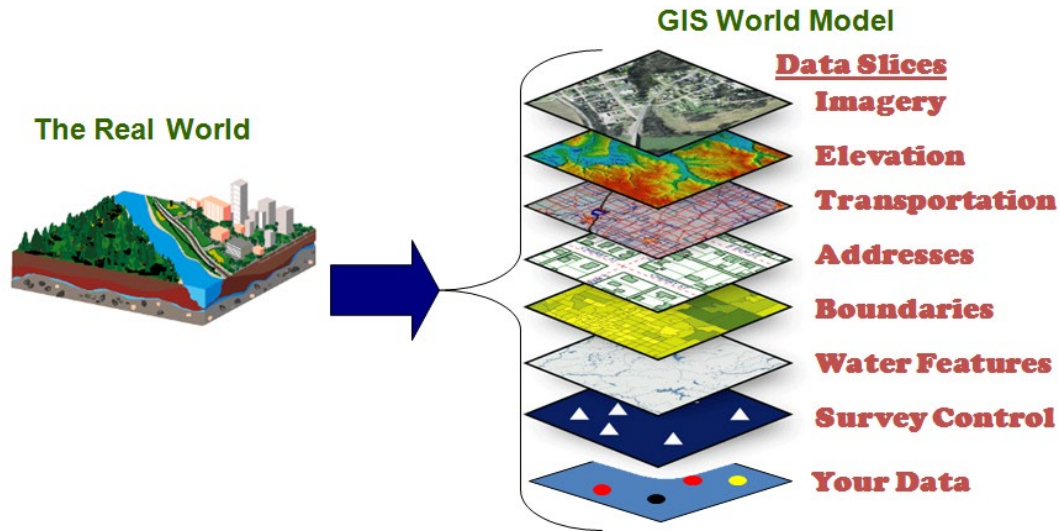
(Shaw, S-L. and Sui, D. 2020. Understanding the new human dynamics in smart spaces and places: Towards a splatial framework, *Annals of the American Association of Geographers*, 110(2), 339-348, DOI: 10.1080/24694452.2019.1631145.)



# Absolute Space

# Absolute Space:

- Locations in absolute space serve as the foundation of conventional GIS that serves many useful applications.



(Source: <https://library.csc.edu/gis/datasources>)



# Relative Space

# Relative Space:

- How many people use (x,y,z) coordinates in absolute space (i.e., location, site) to navigate inside a building?
- Relative locations and surrounding environment (i.e., locale, situation, context) may be more intuitive to human beings.



(Source: <https://www.geospatialworld.net/blogs/indoor-positioning-indoors-gps-stops-working/>)



(Source: <https://www.viewar.com/ar-indoor-navigation/>)

# GIS for Autonomous Vehicles:

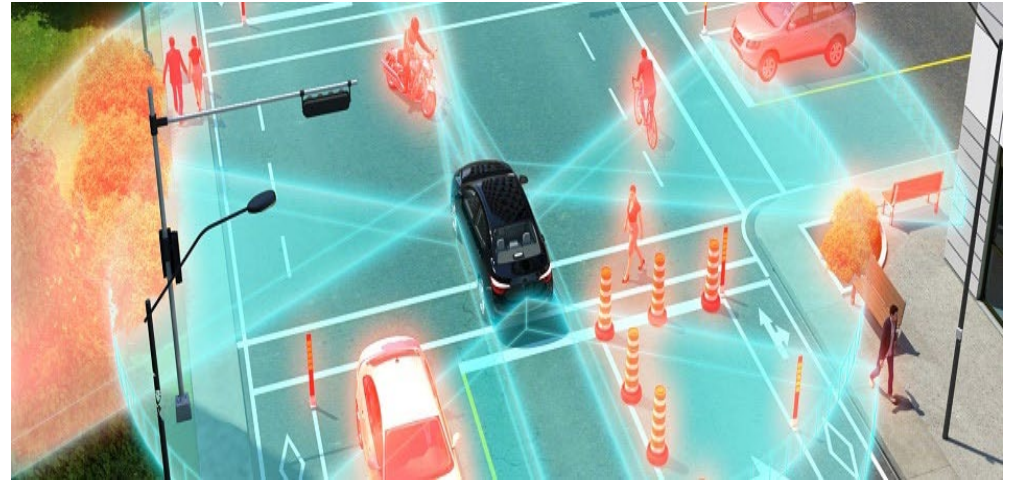
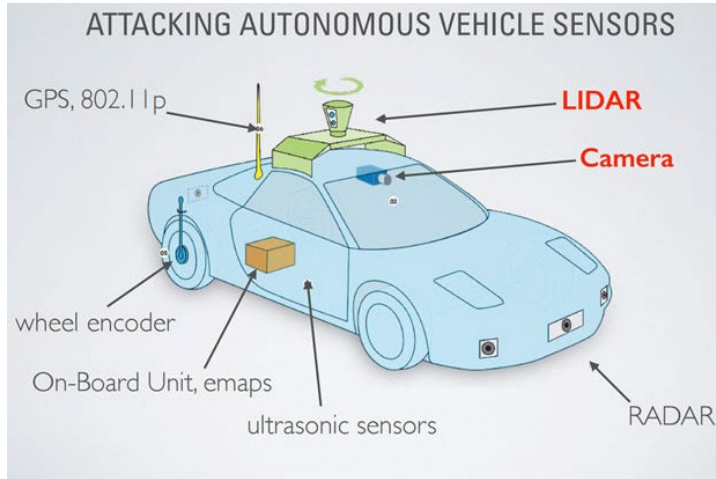
- What is the **positional accuracy** of GIS databases required to support autonomous vehicles?
  - Current in-vehicle navigation: 10 - 15 m
  - Traffic lane: 3 - 5 m
  - Parking: 5 - 10 cm

(Source: Google Images)



# Autonomous Vehicles (Driverless Vehicles):

- Integrating absolute locations with relative locations of surrounding objects can help address many challenges.



(Source: Google Images)



## Privacy-Preserving Contact Tracing

Across the world, governments and health authorities are working together to find solutions to the COVID-19 pandemic, to protect people and get society back up and running. Software developers are contributing by crafting technical tools to help combat the virus and save lives. In this spirit of collaboration, Google and Apple are announcing a joint effort to enable the use of Bluetooth technology to help governments and health agencies reduce the spread of the virus, with user privacy and security central to the design.

As part of this partnership Google and Apple are releasing draft documentation for an Exposure Notification system in service of privacy-preserving contact tracing:

[Exposure Notification - Bluetooth Specification](#)

[Exposure Notification - Cryptography Specification](#)

[Exposure Notification - Framework API](#)

[Exposure Notification - Privacy-Preserving Analytics](#)

[Exposure Notification - Frequently Asked Questions](#)

All of us at Apple and Google believe there has never been a more important moment to work together to solve one of the world's most pressing problems. Through close cooperation and collaboration with developers, governments, and public health providers, we hope to harness the power of technology to help countries around the world slow the spread of COVID-19 and accelerate the return of everyday life.

<https://covid19.apple.com/contacttracing>



<https://news.mit.edu/2020/bluetooth-covid-19-contact-tracing-0409>

# Relational Space

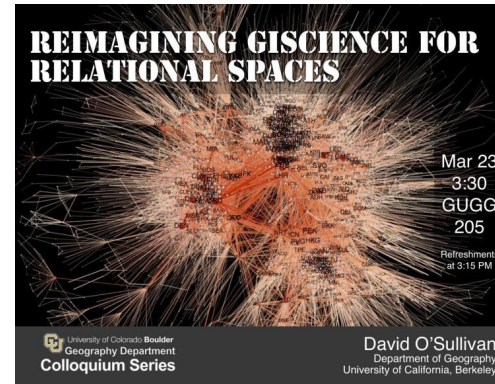


# Relational Space:

- For example, social networks, Zoom meetings, online shopping, etc.
- Focus is on “**topological relations**” and “**individual identity (or place identity)**” rather than “absolute locations”.
- Such relations exist in both **physical space** and **virtual space**.



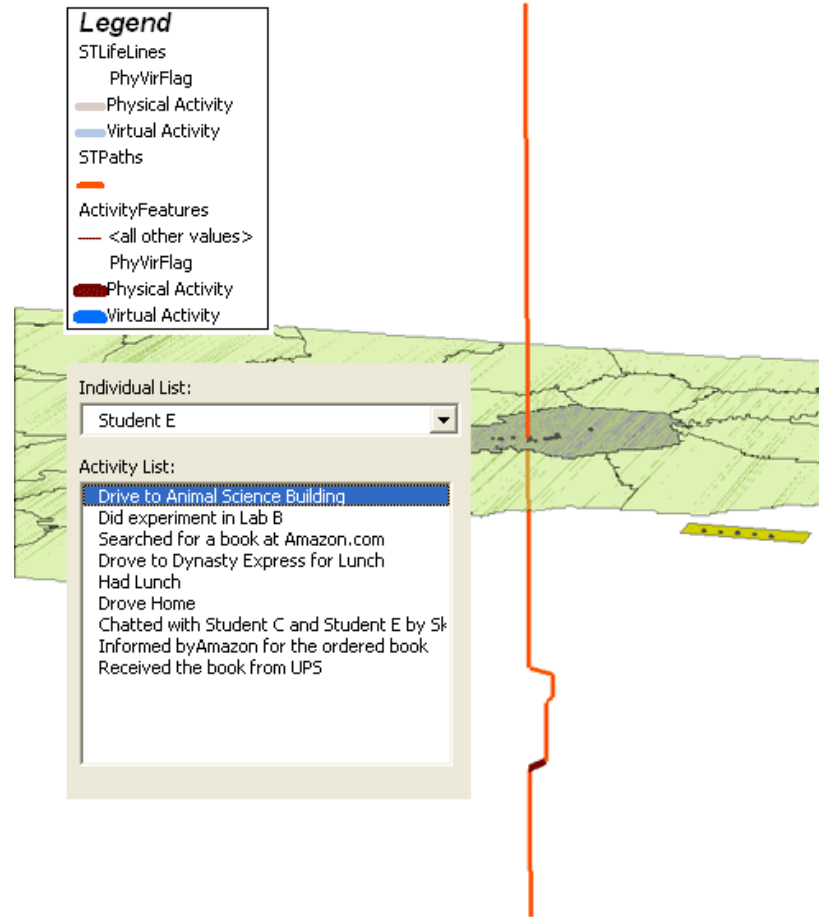
(Source: <https://towardsdatascience.com/the-power-of-weak-ties-f1049c93f3a3>)



(Source: <https://www.colorado.edu/geography/2018/03/23/david-osullivan-reimagining-giscience-relational-spaces>)

# Relational Space:

- An example of integrating **absolute space** and **relational space** based on the concepts of **Time Geography**
- Relational space and absolute space can influence each other.



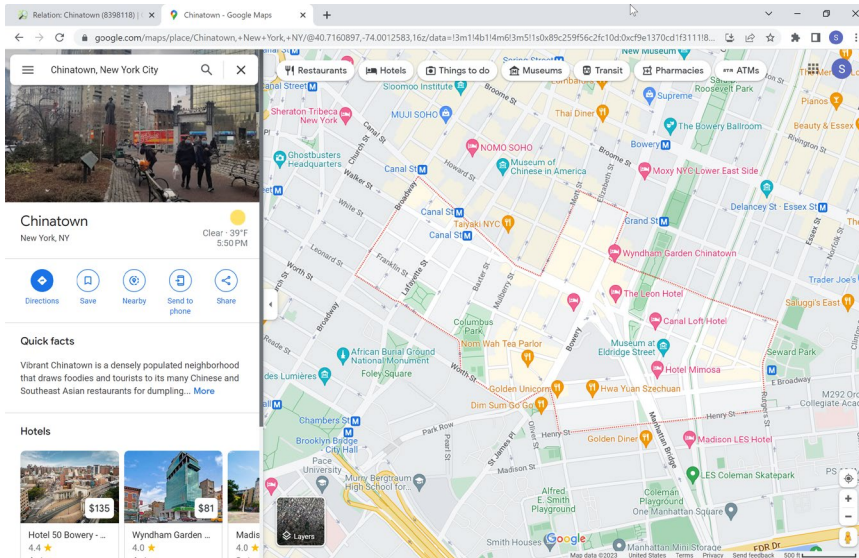
(Shaw & Yu, 2009, Journal of Transport Geography)



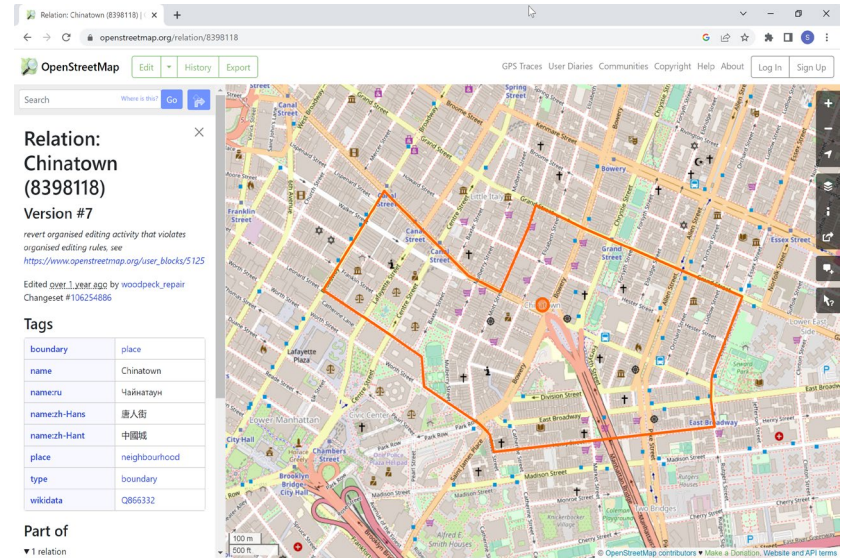
# Mental Space

# Mental Space:

- Focus is on the **mental and cognitive aspects** of humans.
- For example, a search of “Chinatown, New York City”:



Google Maps (March 24, 2023)

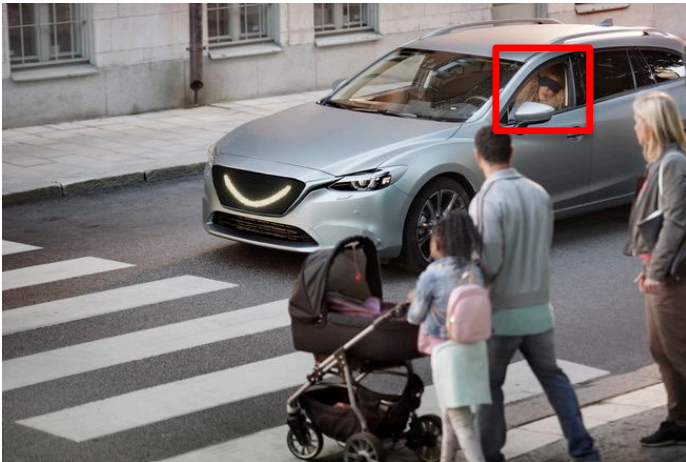


OpenStreetMap (March 24, 2023)



# Autonomous Vehicles – Human Interactions:

- How much do you trust autonomous vehicles?
  - We need **AV-Human communications/interactions**.
  - Autonomous vehicles also need to understand the local context.



(<https://www.popsoci.com/people-want-to-interact-even-with-an-autonomous-car>)



(<https://www.wired.com/2017/01/nissans-self-driving-teleoperation/>)

# Four Types of Space:

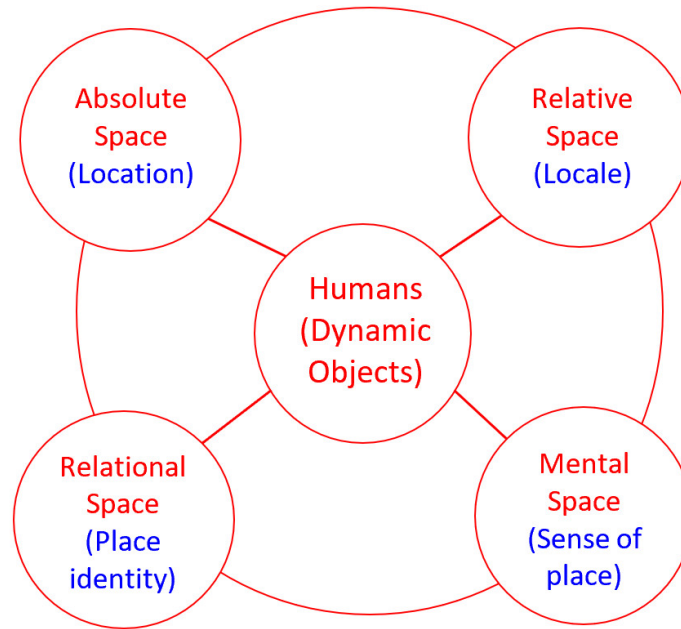
- *Absolute space*: It works with **absolute locations** in space and focuses on questions such as “**where are the different objects?**”
- *Relative space*: It works with **relative locations** to a fixed or moving object and focuses on questions such as “**what are around us?**”
- *Relational space*: It works with **relations** to other objects and focuses on questions such as “**what are related to us?**”
- *Mental space*: It works with the **cognitive and mental aspects** of space and focuses on questions such as “**what do people have in mind?**”

# Integrate “Space” and “Place”:

- First, **absolute space** in the space-place framework is associated with the concept of **location**, which suggests **a specific position or site** that can be conveniently **represented by the coordinates** based on the concepts of absolute space used in conventional GIS.
- The concept of **locale** is closely related to **relative space**. In other words, our attention **focuses mainly on the situation rather than the site** of an object.

- When we deal with **relational space**, the focus shifts to **place identity**. As relational space is based on **topological relations** rather than absolute locations, identity among places or individuals (e.g., online social network) becomes critical in a relational network.
- **Mental space** is associated with **sense of place**, which attempts to reflect what people have in mind about a location, a locale, or a place identity that are associated with absolute space, relative space, and relational space, respectively.

# A Human-Centric, Space-Place (Splatial) GIScience Framework:



# Example 1: Google Maps

(Source: Yung-Ming Tsai's GRA work supervised by Dr. Shih-Lung Shaw at University of Tennessee, Knoxville)



Tupelo Honey Southern Kitchen

Review summary

4.4  
★★★★☆  
2,566 reviews

People also like

Stock & Barrel  
4.7 ★ (3,696)  
American

Web results

https://tu...  
Knoxville

Tupelo Honey traditions rock home. We cr bring ...

✓ Dine-in

1 Mar

Local

Open Wash

Reviews

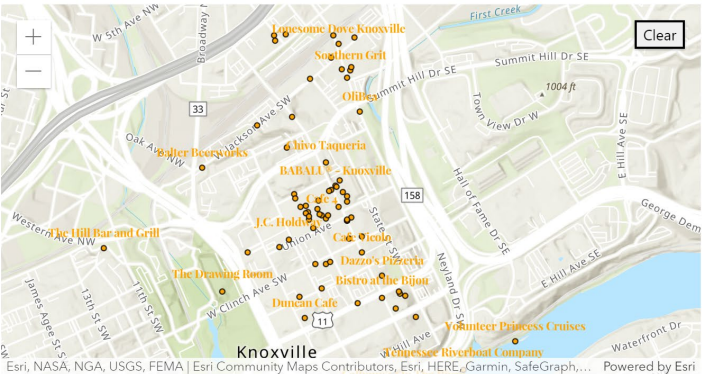
All brussel sprouts 33 jam 29 potato pancakes 25 bloody mary 22 +6

Malgorzata "Gosia" Citko-DuPlantis  
Local Guide · 123 reviews

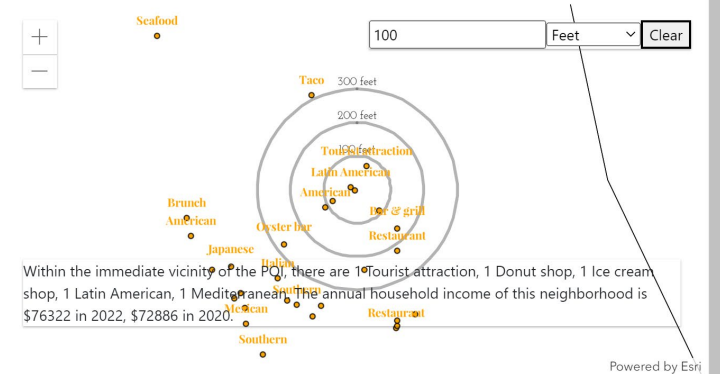
★★★★★ a month ago  
Delicious!  
This place executes southern food so well. My shrimp and grits were wonderfully seasoned but not overbearing. The meatloaf was very flavorful and this

Map showing nearby restaurants, hotels, and landmarks in Knoxville, TN. The restaurant 'Tupelo Honey Southern Kitchen & Bar' is highlighted in red on the map.

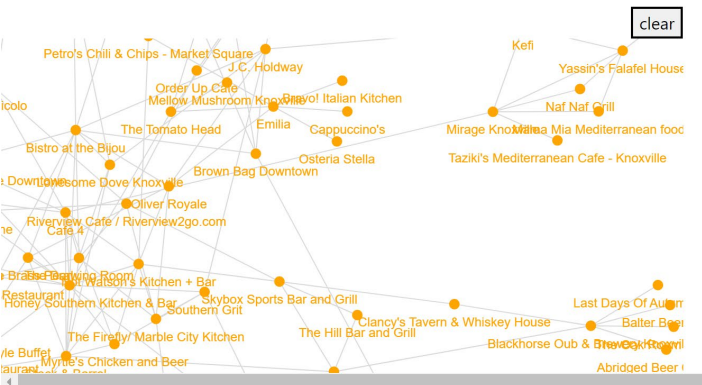
### Absolute View



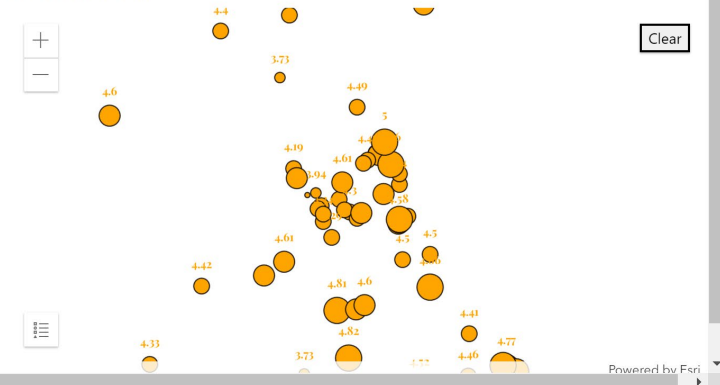
### Relative View



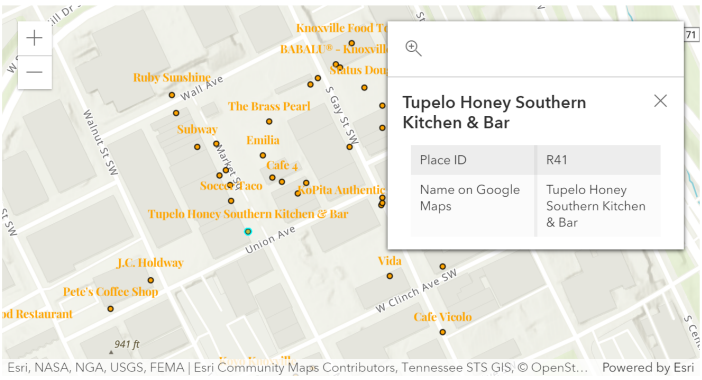
### Relational View



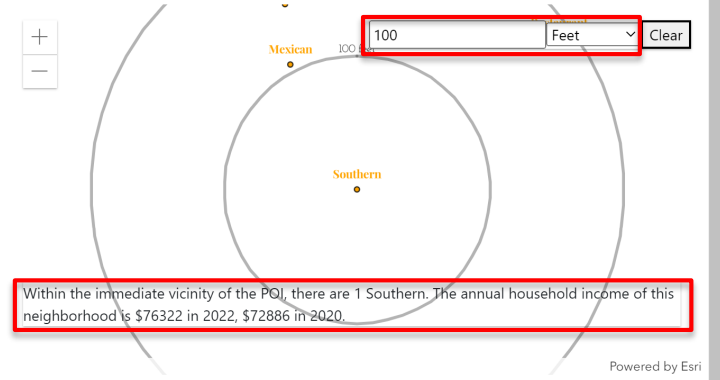
### Mental View



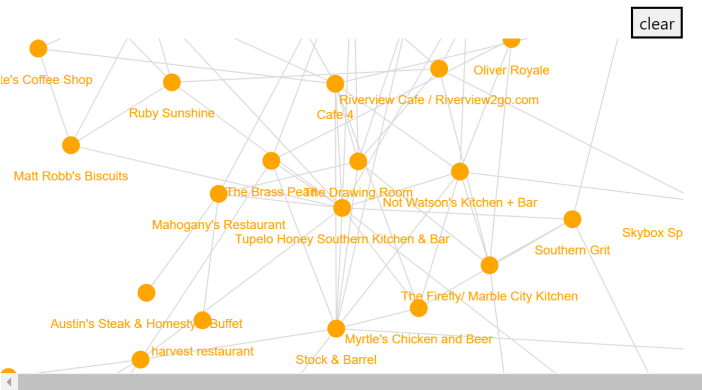
### Absolute View



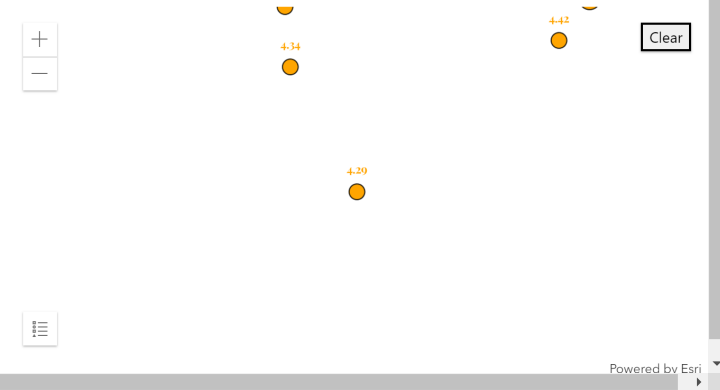
### Relative View



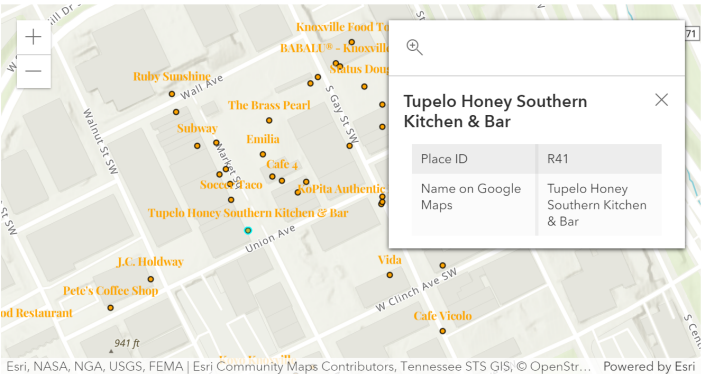
### Relational View



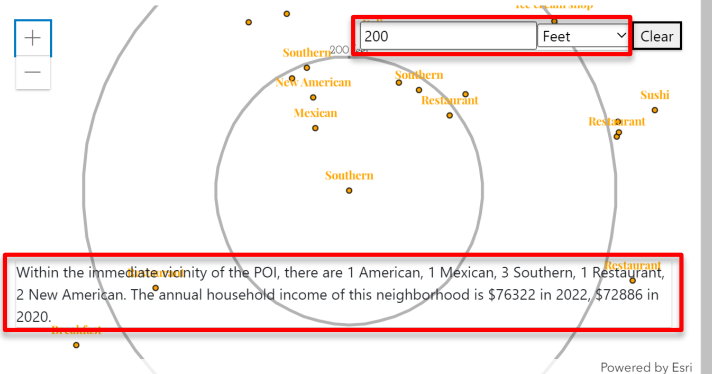
### Mental View



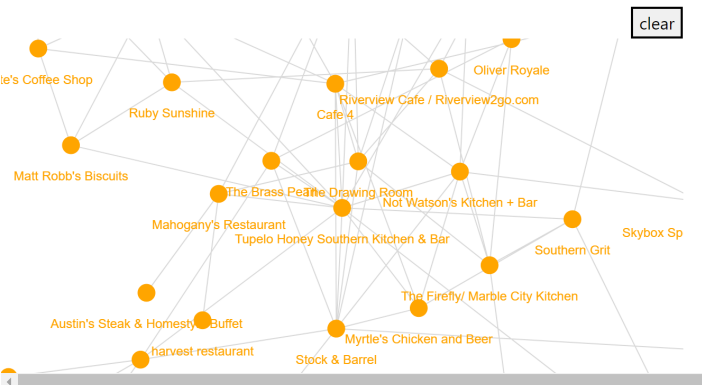
### Absolute View



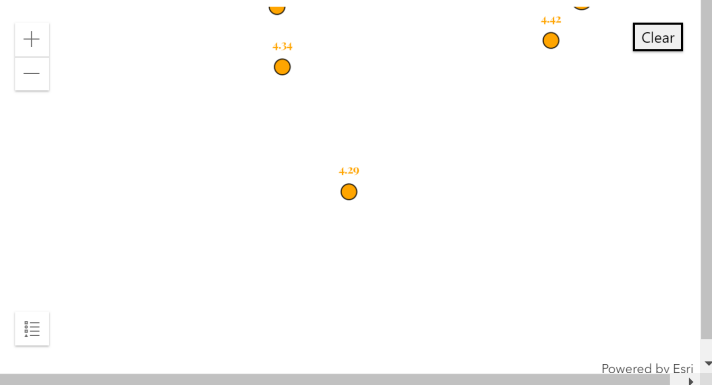
### Relative View



### Relational View



### Mental View





Tupelo Honey Southern Kitchen | SPDM Demo | gmspdm.azurewebsites.net

### Absolute View

### Relative View

200 Feet

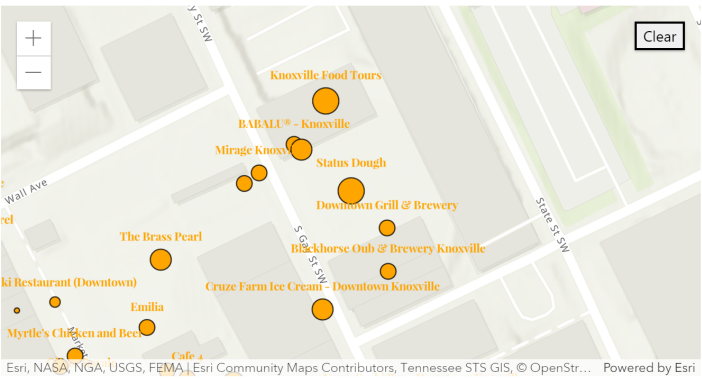
Related to the POI, there are 1 Bistro, 2 Southern, 1 Barbecue, 2 Seafood, 1 Breakfast, 1 New American, 1 Brunch, 2 American, 1 Oyster bar, 1 French, 1 Restaurant

### Relational View

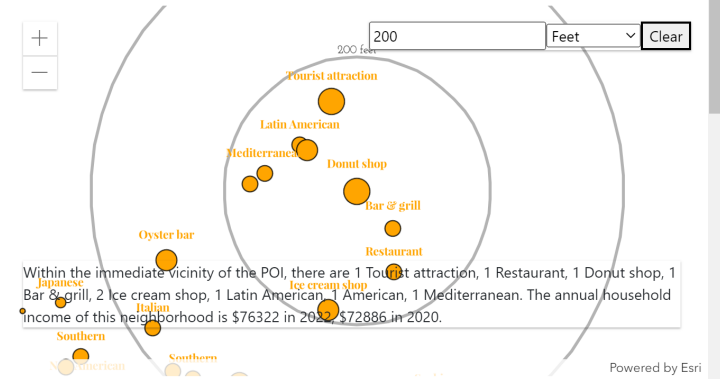
### Mental View

57°F Cloudy | 3:56 PM 2/20/2023

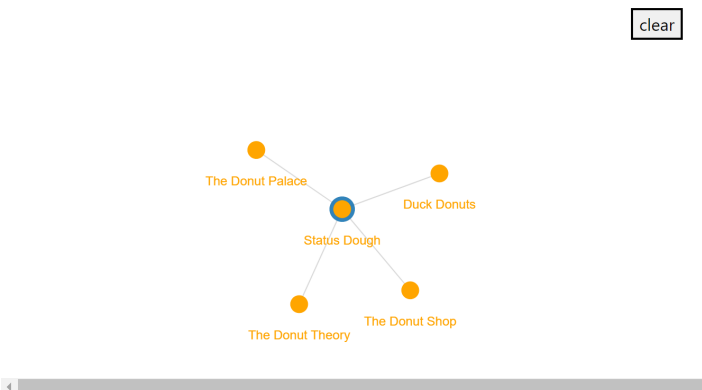
### Absolute View



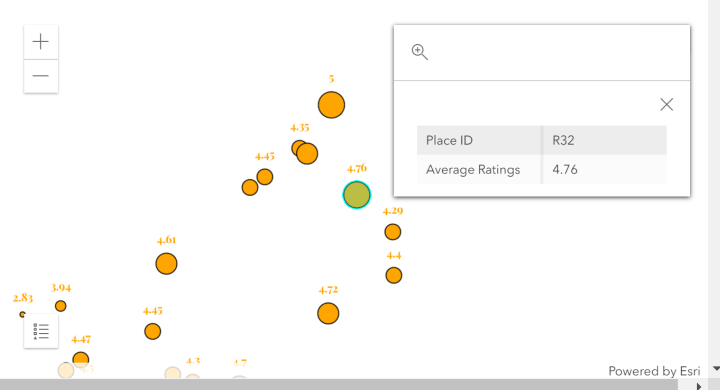
### Relative View



### Relational View



### Mental View



# Example 2: Food Access

(Source: Jimmy Feng's work supervised by Dr. Shih-Lung Shaw at University of Tennessee, Knoxville)

Prototype GIS for Access in a Phy X +

dissertationaccess.herokuapp.com

### Multidimensional Multispace GIS for Access

Total Food Stores 246

Physical 107

Virtual 24

Hybrid 76

[Learn more](#)  
[View Code on GitHub](#)

#### 2D Map of Food Stores and People

03/11/2022 12:00 AM → 03/12/2022 11:59 PM

Select Block Group Choropleth Layer

#### 3D Space-Time Plot of Human Trajectories

#### Food Network

Layout: Concentric

Person Shape: Pentagon

#### Socioeconomic, Demographic, and Perceived Data Tables

Table: Individuals

Table: Food Stores

Store Name	Rating	Price	Type	Specific Type	Convenience	Checkout
United Grocery Outlet	4.3		Grocery store	Grocery store		
Ingles Markets	4.3	\$\$	Grocery store	Grocery store		
Ingles Markets	4.4	\$\$	Grocery store	Supermarket		
ALDI	4.5	\$	Grocery store	Supermarket		

Type here to search

74°F Sunny 10:03 AM 8/14/2022



# Multidimensional Multispace GIS for Access

249  
 Total Food Stores

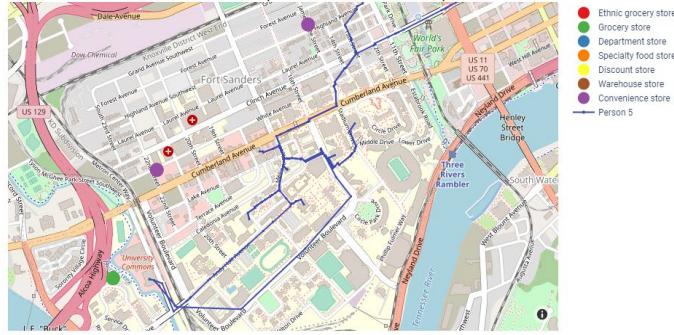
62  
 Physical

55  
 Virtual

35  
 Hybrid

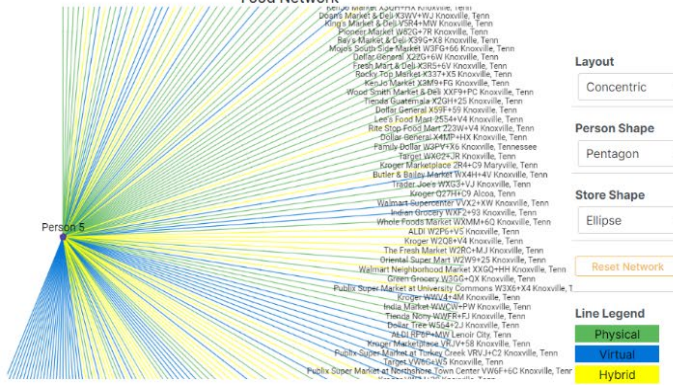
[Learn more](#)  
[View Code on GitHub](#)

### 2D Map of Food Stores and People



03/12/2022 11:50 AM → 03/12/2022 11:59 PM Select Block Group Choropleth Layer

### Food Network



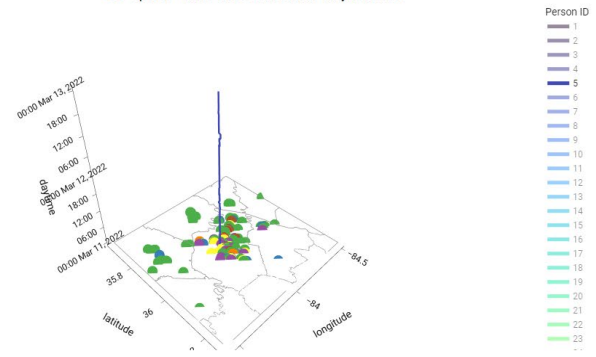
**Layout**

**Person Shape**

**Store Shape**

**Line Legend**

### 3D Space-Time Plot of Human Trajectories



### Socioeconomic, Demographic, and Perceived Data Tables

Table: Individuals		Table: Food Stores					
ID	Name	Rating	Price	Type	Specific Type	Convenience	Checkout Process
filter data...							
	Kroger Marketplace	4.3	\$\$	Grocery store	Grocery store	3.67	3.48
	Far East Market (Asian Groceries Store)	4.6		Ethnic grocery store	Asian grocery store	3.88	3.33
	Sunrise Supermarket 上頂超市	4.4		Ethnic grocery store	Asian grocery store	3.23	3.17
	Tienda Nony	4.5		Grocery store	Grocery store		4
	Mediterranean Food Market	4.5		Ethnic grocery store	Asian grocery store	3.36	3.31
	India Market	4.5		Grocery store	Grocery store	4.12	3.59
	Target	4.1	\$\$	Department store	Department store	3.52	3.17
	Butler & Bailey Market	4.5		Grocery store	Supermarket	3.44	3.78
	Trader Joe's	4.7	\$\$	Grocery store	Grocery store	3.57	3.38
	Indian Grocery	4.6		Grocery store	Grocery store	3.75	3.63
	Whole Foods Market	4.3	\$\$\$	Grocery store	Grocery store	3.44	3.45
	ALDI	4.6	\$	Grocery store	Supermarket	3.53	3.68
	Kroger	4.2	\$\$	Grocery store	Grocery store	3.32	3.49

# Multidimensional Multispace GIS for Access

Total Food Stores **245**

Physical **58**

Virtual **0**

Hybrid **0**

[Learn more](#)

[View Code on GitHub](#)

### 2D Map of Food Stores and People

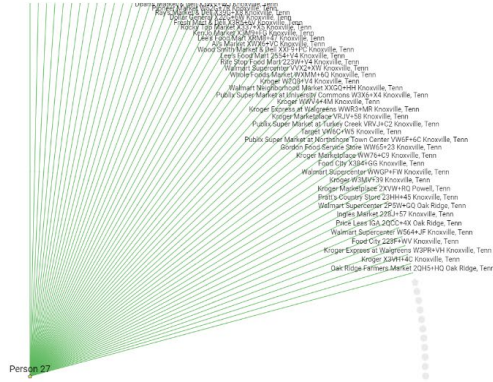


03/11/2022 12:00 AM

→ 03/12/2022 11:59 PM

Select Block Group Choropleth Layer

### Food Network



#### Layout

Concentric

#### Person Shape

Pentagon

#### Store Shape

Ellipse

[Reset Network](#)

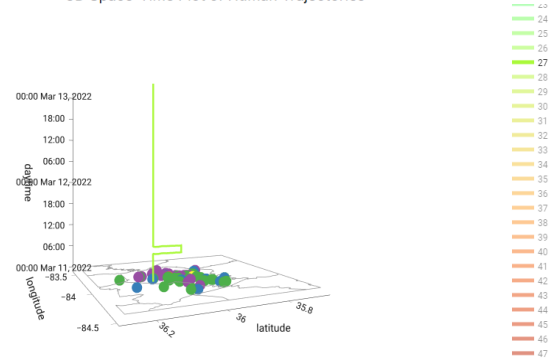
#### Line Legend

Physical

Virtual

Hybrid

### 3D Space-Time Plot of Human Trajectories



### Socioeconomic, Demographic, and Perceived Data Tables

Table: Individuals		Table: Food Stores					
Store Name	Rating	Price	Type	Specific Type	Convenience	Checkout Process	Employ
Kroger Marketplace	4.4	\$\$	Grocery store	Grocery store	3.17	3.45	3
Publix Super Market at Turkey Creek	4.7	\$\$	Grocery store	Supermarket	3.73	3.59	3
Target	4.5	\$\$	Department store	Department store	3.39	3.58	3
Publix Super Market at Northshore Town Center	4.7	\$\$	Grocery store	Supermarket	3.65	3.7	3
Gordon Food Service Store	4.6		Grocery store	Grocery store	3.75	3.26	3
Kroger Marketplace	4.3	\$\$	Grocery store	Grocery store	3.67	3.48	3
Kroger	4.2	\$\$	Grocery store	Grocery store	3.25	3.27	3
Walmart Supercenter	3.9	\$	Department store	Department store			3
Whole Foods Market	4.3	\$\$\$	Grocery store	Grocery store	3.44	3.45	3
Kroger	4.2	\$\$	Grocery store	Grocery store	3.32	3.49	3
Walmart Neighborhood Market	4.3	\$	Grocery store	Supermarket	3.44	3.22	3
Publix Super Market at University Commons	4.6	\$\$	Grocery store	Supermarket	3.67	3.54	3
Kroger Express at Walgreens	4.7		Grocery store	Grocery store	4.55	4	3

# Multidimensional Multispace GIS for Access

Total Food Stores
245

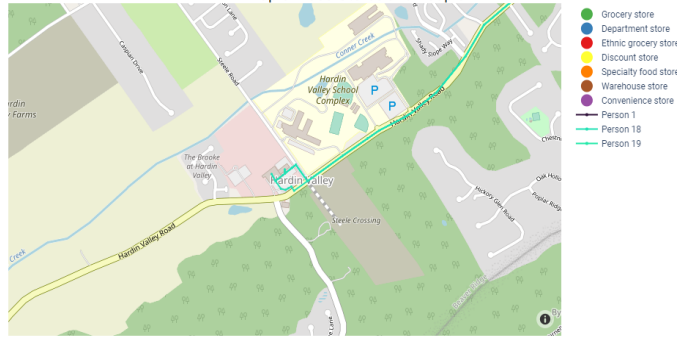
Physical
161

Virtual
8

Hybrid
9

[Learn more](#)  
[View Code on GitHub](#)

### 2D Map of Food Stores and People



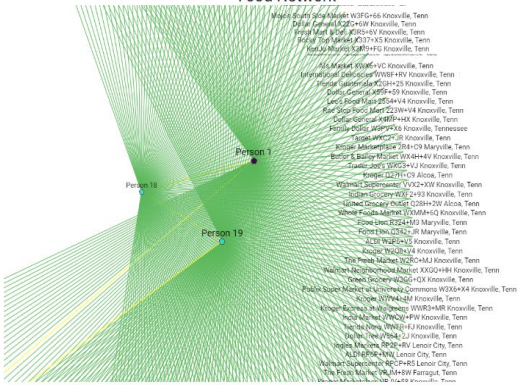
03/11/2022 12:00 AM

→

03/12/2022 11:59 PM

Select Block Group Choropleth Layer

### Food Network



#### Layout

Concentric

#### Person Shape

Pentagon

#### Store Shape

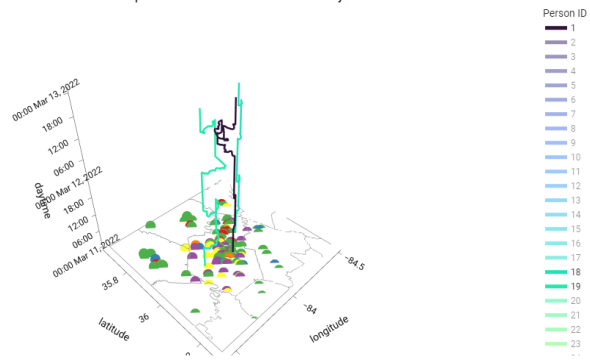
Ellipse

Reset Network

#### Line Legend

- Physical
- Virtual
- Hybrid

### 3D Space-Time Plot of Human Trajectories



Instant Delivery Same-Day Delivery Masks Required Great Service Wheelchair Accessible Good for Quick Visit Organic Food Prepared Food Accessible

	Instant Delivery	Same-Day Delivery	Masks Required	Great Service	Wheelchair Accessible	Good for Quick Visit	Organic Food	Prepared Food	Accessible
Person 1	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Person 18	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Person 19	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Person 2	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Person 3	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Person 4	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Person 5	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Person 6	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Person 7	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Person 8	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Person 9	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Person 10	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Person 11	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Person 12	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Person 13	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Person 14	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Person 15	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Person 16	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Person 17	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Person 18	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Person 19	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Person 20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Person 21	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Person 22	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Person 23	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

## Concluding Remarks:

- This **Human-Centered Space-Place GIScience Framework** is closer to human thinking.
- This framework can make GIS/GIScience more relevant and useful to studies in **many fields that need to address various human needs**.
- This framework can better support human dynamics research in a **hybrid physical-virtual world**.
- This framework will require further work to improve and implement it. **I look forward to collaboration with you!**

*Thank You!*

**Questions, Comments & Suggestions?**

For additional information,  
Contact Shih-Lung Shaw at [sshaw@utk.edu](mailto:sshaw@utk.edu)