A CyberGIS Enabled Multi-Criteria Spatial Decision Support System: a Case Study on Flood Emergency Management

Zhe Zhang (Texas A&M University);
Hao Hu (University of Illinois at Urbana-Champaign);
Dandong Yin (University of Illinois at Urbana-Champaign);
Shakil Kashem (University of Illinois at Urbana-Champaign);
Ruopu Li, (Southern Illinois University);
Heng Cai (Louisiana State University);
Dylan Perkins (University of Wyoming),
Shaowen Wang (University of Illinois at Urbana-Champaign)
04.04.2019

Motivations:

- Each type of emergency responder usually responds to a disaster according to its professional responsibilities
- Conflicting objectives
- Various data sources with different formats and scales

Data:

- Census data
- Twitter data
- Flood hazard map
- NOAA storm events database

CyberGIS

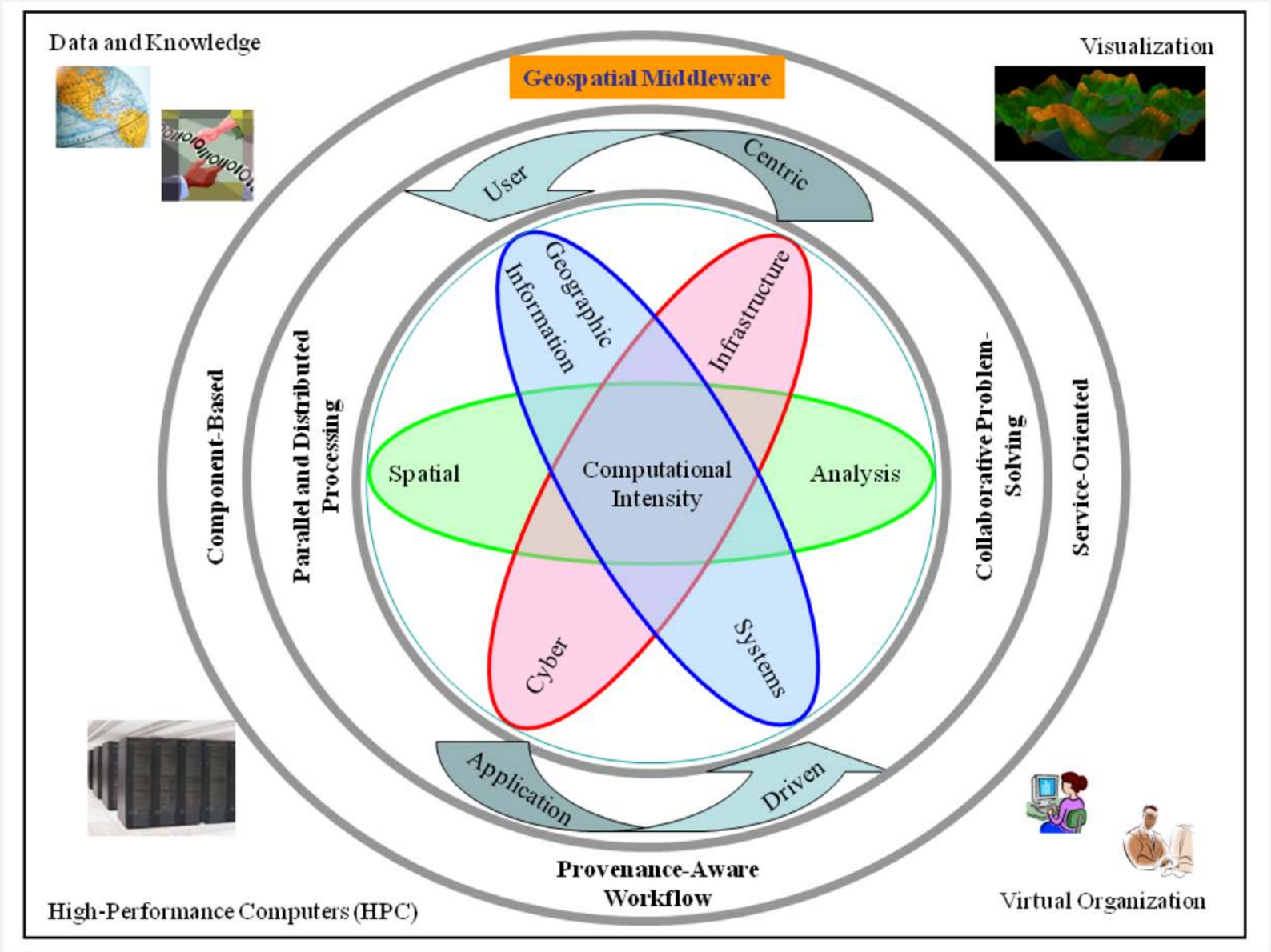
CyberGIS is Geographic Information Science and Systems based on advanced cyberinfrastructure.

Cyberinfrastructure includes:

- High-performance computing systems
- Data storage systems
- Advanced instruments
- Data repositories
- Visualization environments
- People
- Linked by high speed networks

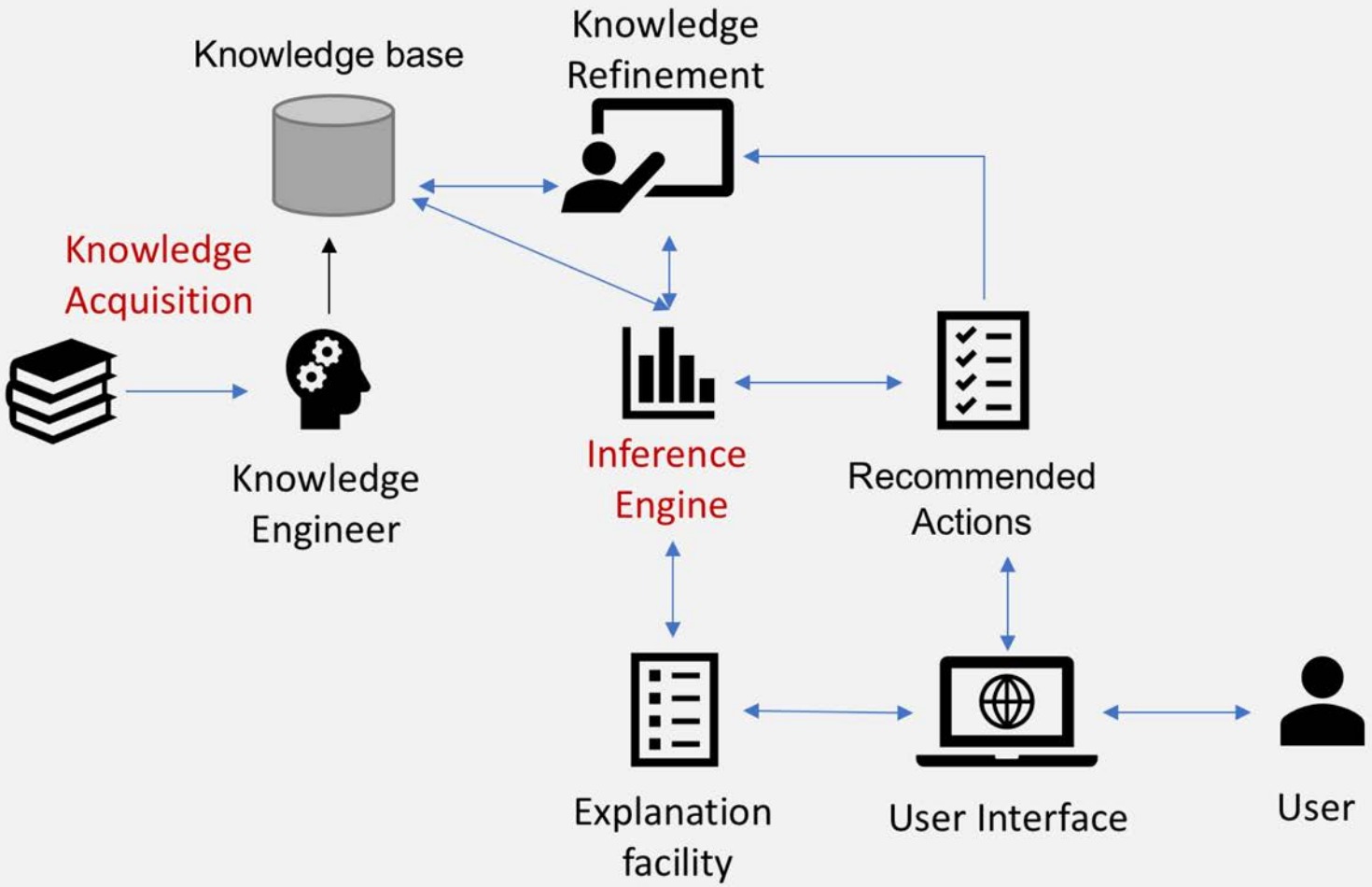
CyberGIS

- Motivation
- Concept
- Research Questions
- Method
- Results
- Future Work



Intelligent Decision Support System - An Expert System Workflow

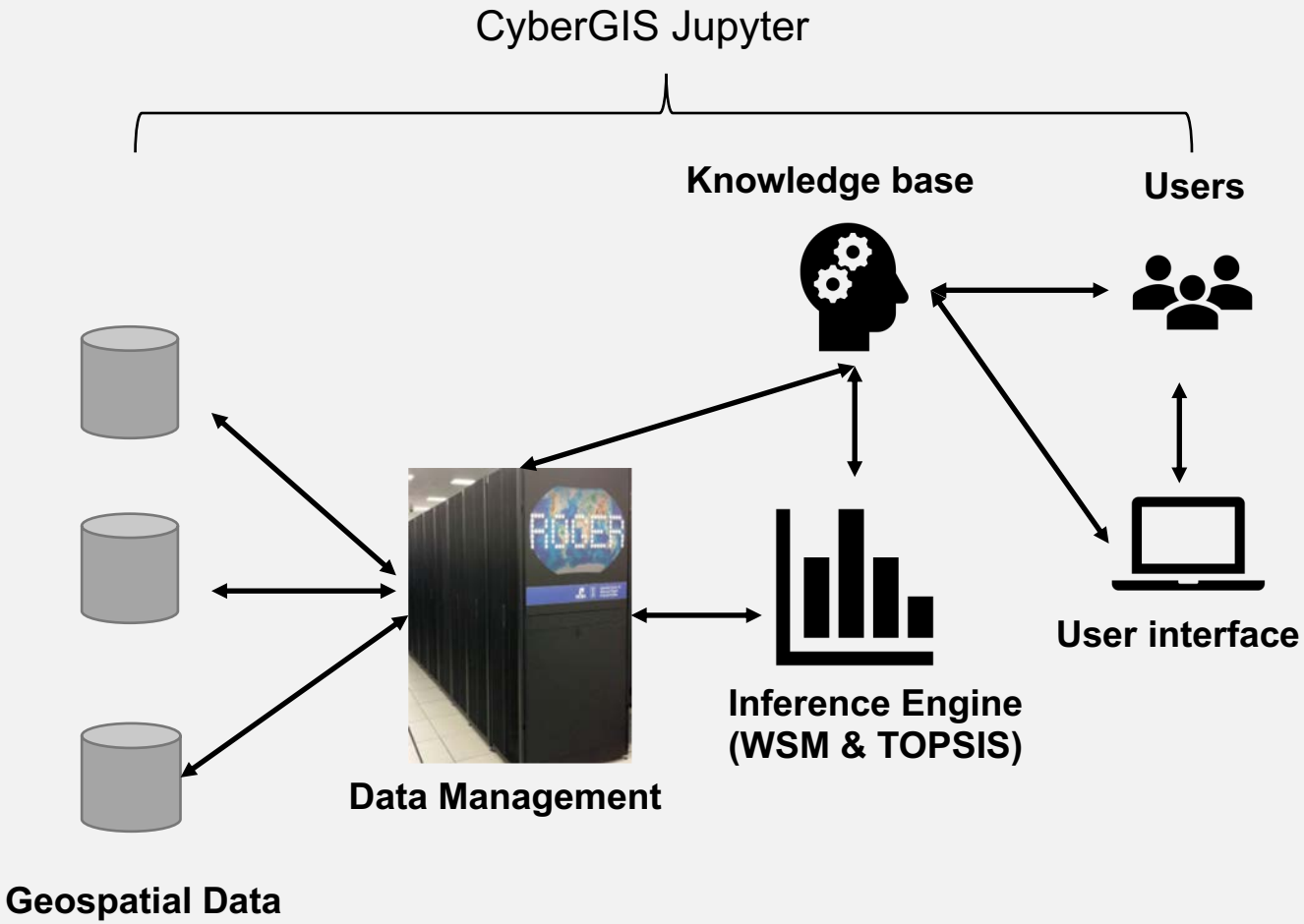
- Motivation
- Concept
- Research Questions
- Method
- Results
- Future Work



Turban, E., and Aronson, J., 2000. Decision support systems and intelligent systems. Prentice Hall: Upper Saddle River: New Jersey.

Decision Goal 1: which area should a rescue personnel go to first in order to save more lives?
Decision Goal 2: which area had the most significant economic loss and needs the greatest financial support to recover from a flooding event?

- Motivation
- Concept
- Research Questions
- Method
- Results
- Future Work



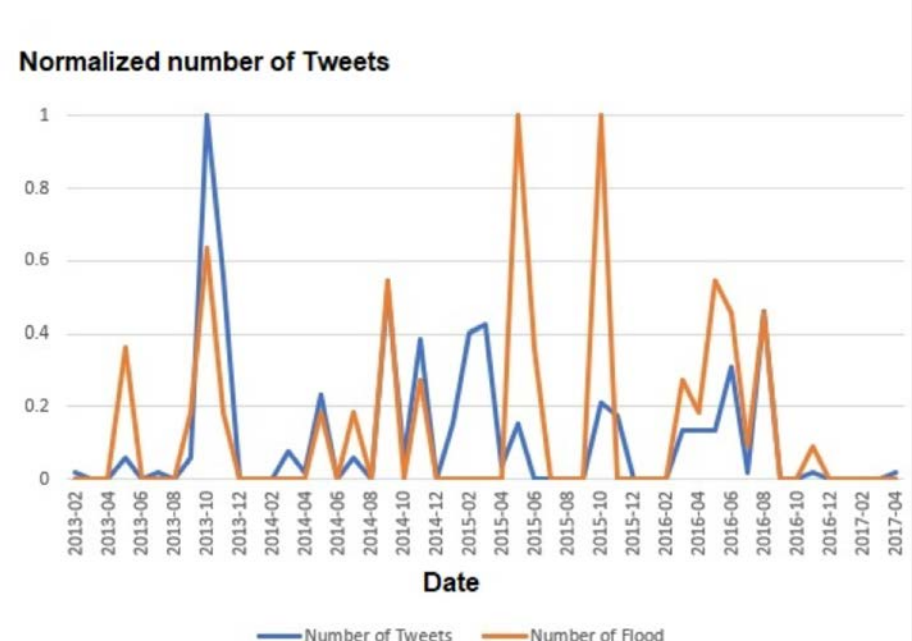
Social Media Data Analysis

- Motivation
- Concept
- Research Questions
- Method
- Results
- Future Work

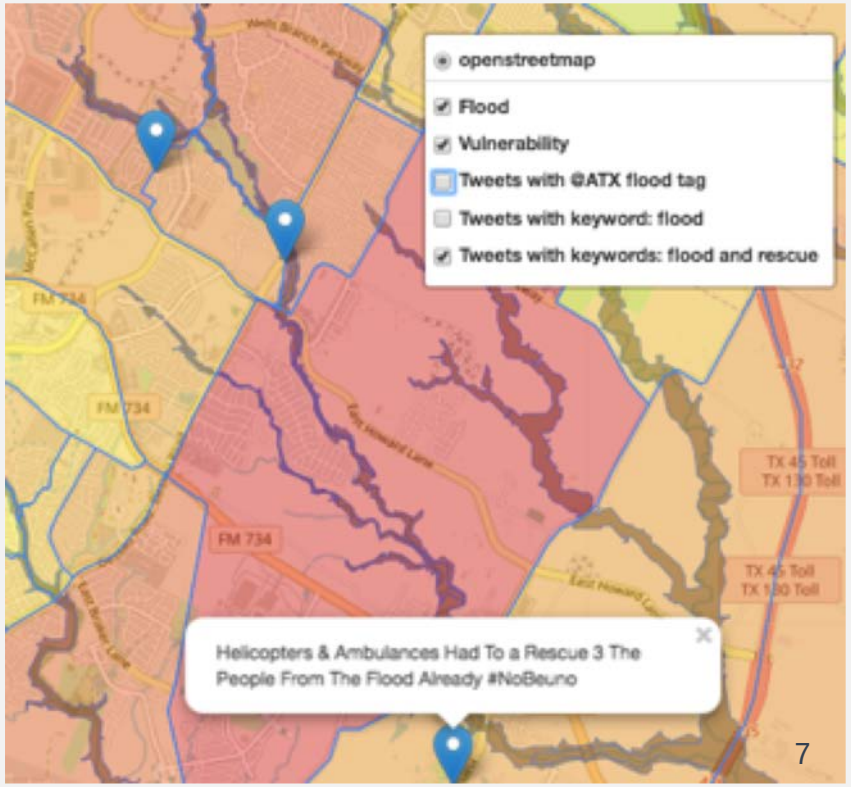
Step 1

18382	I	5330	on	2775	have
16581	to	5166	this	2697	Austin
15493	the	5019	TX	2680	#job
13626	a	4859	me	2654	was
11868	in	4403	be	2511	#CareerArc
8893	and	4231	#Hiring	2505	are
8499	my	4209	with	2495	&
8486	you	3976	#Austin,	2481	#Jobs
8404	@	3715	it	2471	out
8399	for	3599	that	2430	up
8384	at	3314	so	2252	#Job
6776	I'm	3183	just	2250	Texas
6725	of	2981	Austin,	2207	get
6666	is	2827	The	2134	all
6592	😂	2827	like	2134	about
6266		2799	our	2118	This
5854	-	2789	TX)		

Step 2

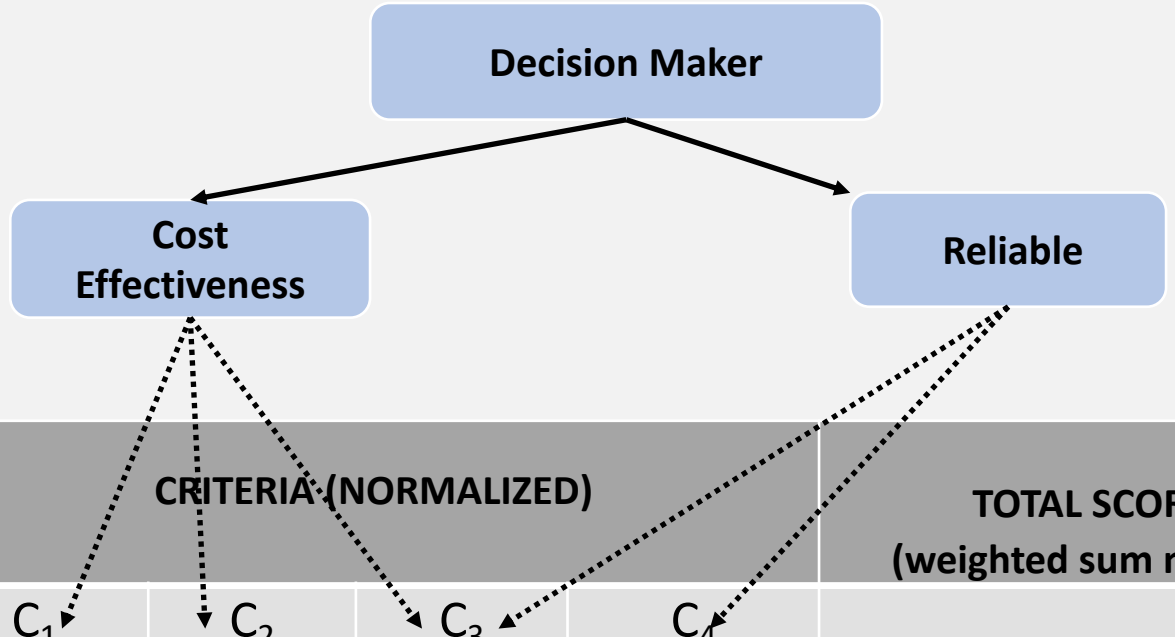


Step 3



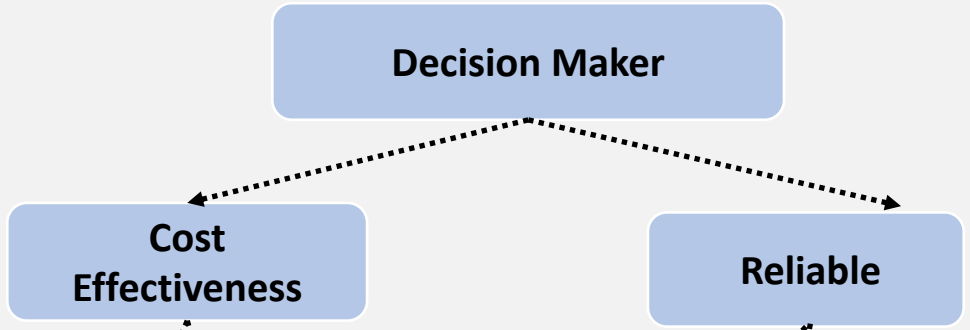
Multi-Criteria Decision Making: Weighted Sum Model

- Motivation
- Concept
- Research Questions
- Method
- Results
- Future Work



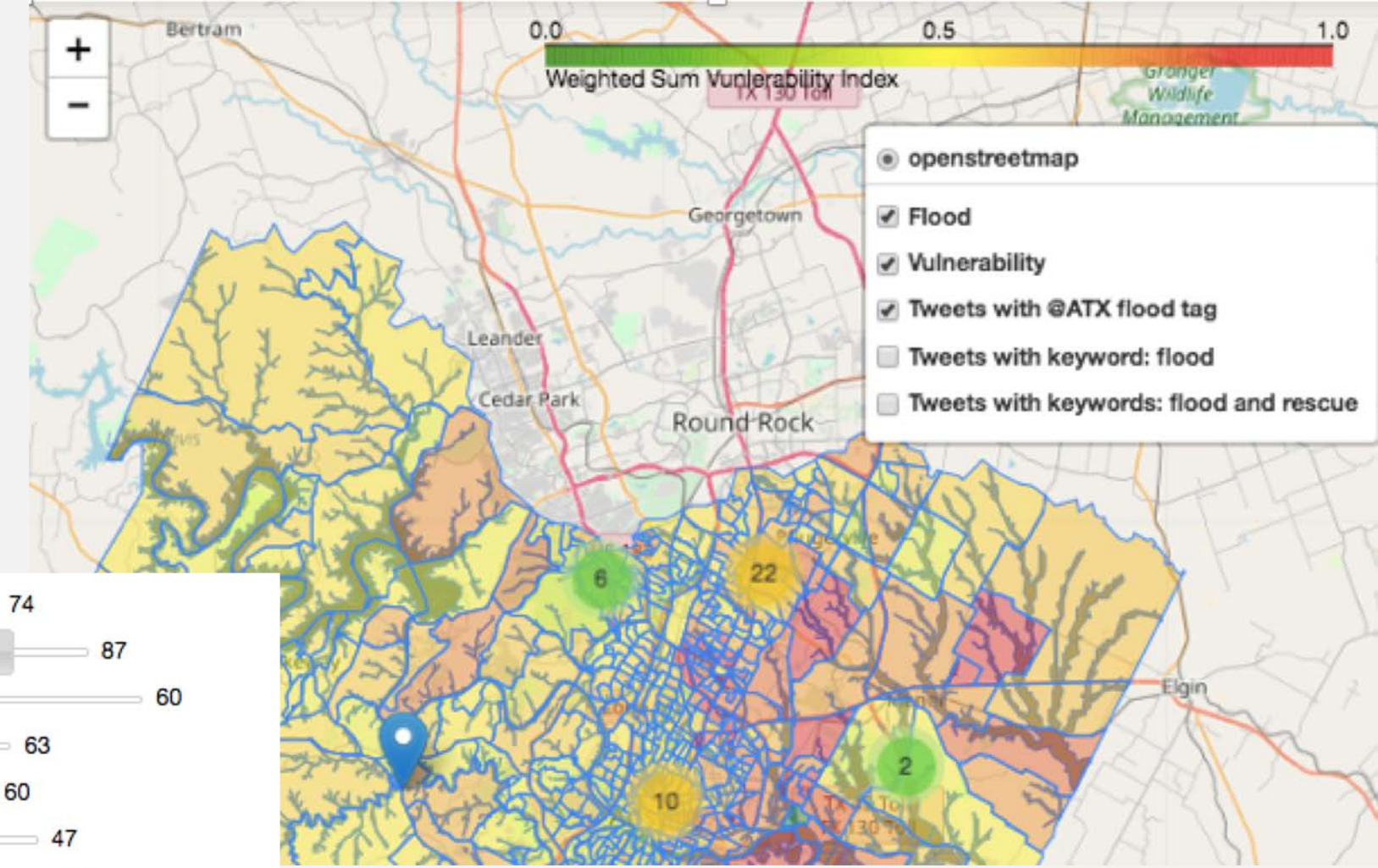
ALTERNATIVE	CRITERIA (NORMALIZED)				TOTAL SCORE (weighted sum model)
	C_1	C_2	C_3	C_4	
	Make	Repair Cost	Price	Year of production	Weighted Sum Model
Weight	W_1	W_2	W_3	W_4	
Audi A4	a_{11}	a_{12}	a_{13}	a_{14}	$a_{11}\times w_1+a_{12}\times w_2+\ldots+a_{16}\times w_6$
Toyota Camry	a_{21}	a_{22}	a_{23}	a_{24}	$a_{21}\times w_1+a_{22}\times w_2+\ldots+a_{26}\times w_6$

Multi-Criteria Decision Making: TOPSIS Model



ALTERNATIVE	CRITERIA (NORMALIZED)				POSITIVE SEPARATION	NEGATIVE SEPARATION	TOTAL SCORE TOPSIS
	C_1	C_2	C_3	C_4	S_j^*	S_j^-	
	Repair Cost	Price	Make	Miles Driven			
Weight	W_1	W_2	W_3	W_4			
Audi A4	$V_{11}=a_{11}*W_1$	V_{12}	V_{13}	V_{1j}	$\sqrt{\sum(V_{ij} - V_j^*)^2}$	$\sqrt{\sum(V_{ij} - V_j^-)^2}$	$\frac{S_j^-}{S_j^* + S_j^-}$

User Interface



Total population : 74

People over 75 years old : 87

Peole without health insurance: 60

People in poverty : 63

Minority people : 60

Median house value : 47

Education attainment : 41

People under 5 years old : 93

People with no vehicle : 78

Submit WSM

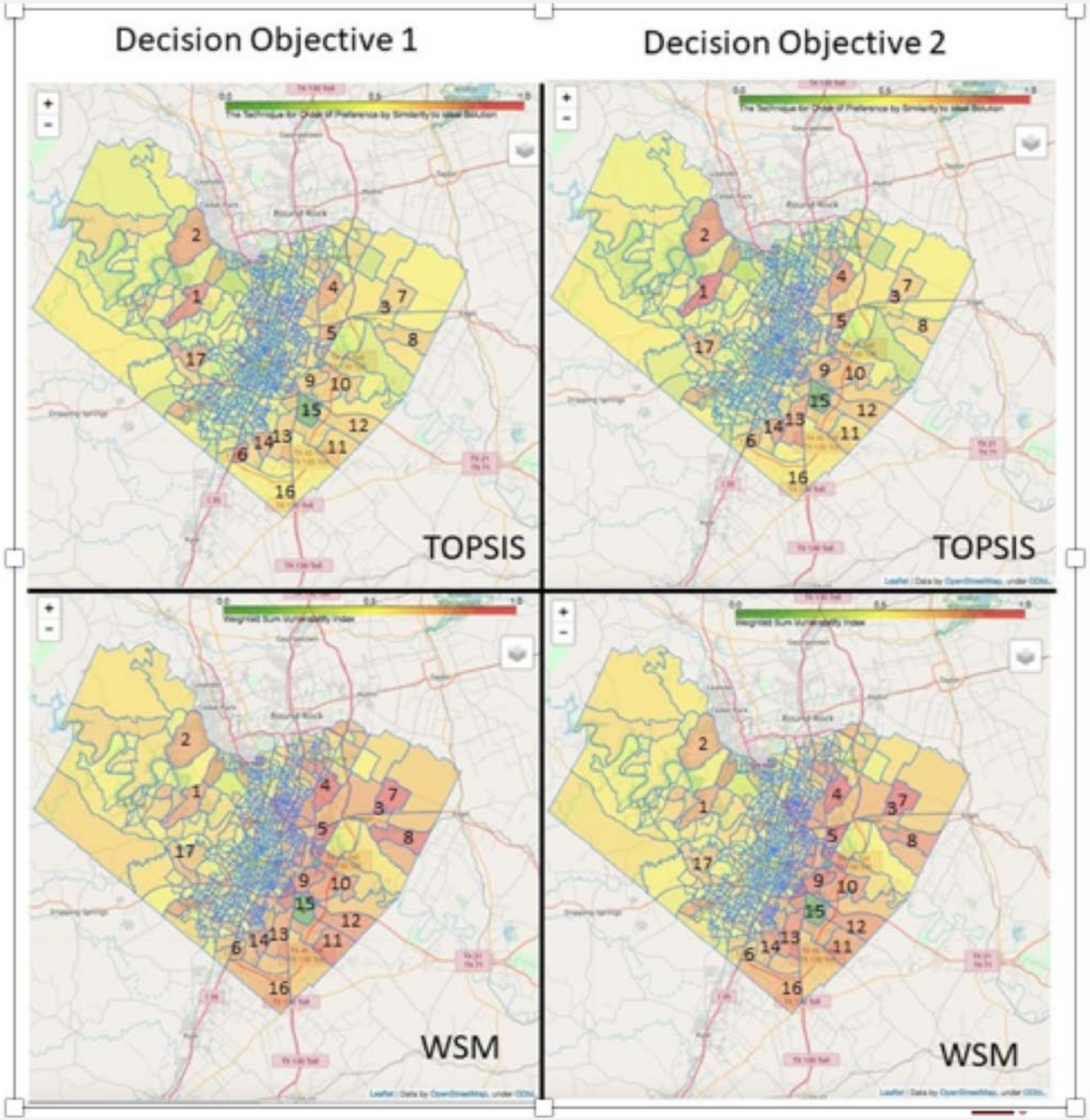
Submit TOPSIS

Single User

A Group of Users

Results

Evaluation Criteria	Decision goal 1	Decision goal 2
Total population	74	83
People over 75 years old	87	70
People without health insurance	60	82
People in poverty	63	83
Minority group	60	68
Area median house value	47	66
Education attainment	41	56
Number of children	93	79
People without a vehicle	78	58



Sensitivity Analysis

- Motivation
- Concept
- Research Questions
- Method
- Results
- Future Work

Criteria	Objective 1 (Rank of Criticality Degrees of the Criteria)		Objective 2 (Rank of Criticality Degrees of the Criteria)	
	TOPSIS	WSM	TOPSIS	WSM
Total population	3	5	2	5
People over 75 years old	2	4	5	6
People without health insurance	7	3	6	1
People in poverty	5	6	3	4
People in a minority group	6	7	4	7
Area median house value	9	9	7	9
Education attainment	8	8	9	8
Number of children	4	1	8	2
People without a vehicle	1	2	1	3

- Motivation
- Concept
- Research Questions
- Method
- Results
- Future Work

Model Validation

Blocks	WSM Model		TOPSIS Model	
	Objective 1	Objective 2	Objective 1	Objective 2
1	0.1	0	0	0.2
2	0.8	0.8	0.8	0.8
3	0.2	0.1	0.2	0.1
4	0.4	0.5	0.4	0.5
5	0.6	0	0.5	0.1
6	0.2	0.3	0.4	0.4
7	0.8	0.1	0.9	0
8	0.3	0	0.4	0.1
9	0.4	0.1	0.4	0.1
10	0.6	0.5	0.4	0.3
Average Error	0.44 (44%)	0.24 (24%)	0.48 (48%)	0.26 (26%)

- Motivation
- Concept
- Research Questions
- Method
- Results
- Future Work

1.Developed a decision support tool that combines high-performance geospatial computing, advanced decision-making techniques, and various types of social indicators for flood hazard management.

2. The major objective is to create a program that allows for better communication between citizens and emergency management and provides consistent results.

3. Twitter text mining techniques can be used to categorize tweets in order to support different types of decision problems.

5. More indicators such as income status of the family, family structures, and housing characteristics should be included in order to make the framework more useful for different kinds of disaster scenarios.

Thank You !
Questions ?

Contact:
Zhe Zhang
zhezhang@tamu.edu