A Fuzzy Logic Based System for Geolocated Augmented Reality Field Service Support

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Outline

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- Introduction

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Motivation

Challenge for Augmented Reality (AR) based field service tools;

- Helping users to move to the correct location where the company's assets and infrastructure located in the field.

The Proposed AR system is based on fuzzy logic mechanisms;

- Provides the user with directions for asset location by comparing user's current position with asset's location in real time.

Introduction

- Augmented Reality (AR) tries to solve the challenge of physical/virtual world's exclusion from one another by adding computer-generated objects and combining them with physical elements in a shared environment to make them appear as if they co-exist in the same direction.

- AR-based field service applications face difficulty in providing information to move the user to the correct location because of the uncertainty generated by sensors and human error.

- The Fuzzy Logic System will deal with that problem and provide field service engineers with directions to reach specific assets based on private maps.

Proposed Fuzzy Logic Based System
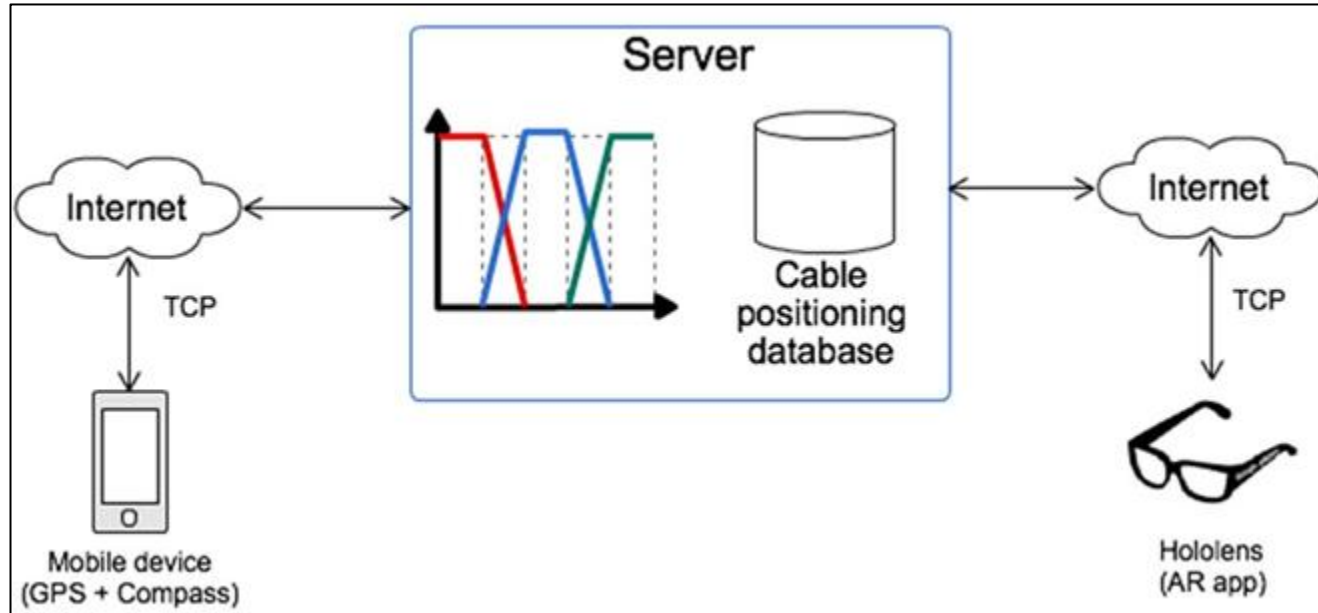
Conceptual Model of the System

Proposed Fuzzy Logic Based System

- A mobile device captures location and orientation of the engineer, based on GPS and compass sensor information.

- Engineer's latitude and longitude is captured in decimal degrees (DD).

- This information is sent to the server, in the server, a software agent obtains the DD coordinates of the selected asset from the main database, and calculates the difference between engineer's position and asset's position.

- The difference is used as the input to the Fuzzy Logic inference system, which provides two outputs: direction and movement.

Head Mounted Display (HDM)

- The software agent process the output to provide the user with human-understandable instructions to locate the asset.
- Finally, the instructions are sent to the head-mounted display (HDM) then the engineer can hear them using text to voice functionality and visualize the asset location when it has arrived at the goal location.

AR smart glasses : Microsoft HoloLens is used
Only relevant information is displayed
Information is automatically available when needed,
and can be enriched with additional online information
flexibility , can be used hands-free

Microsoft HoloLens

Compass Rose and Positioning Diagram
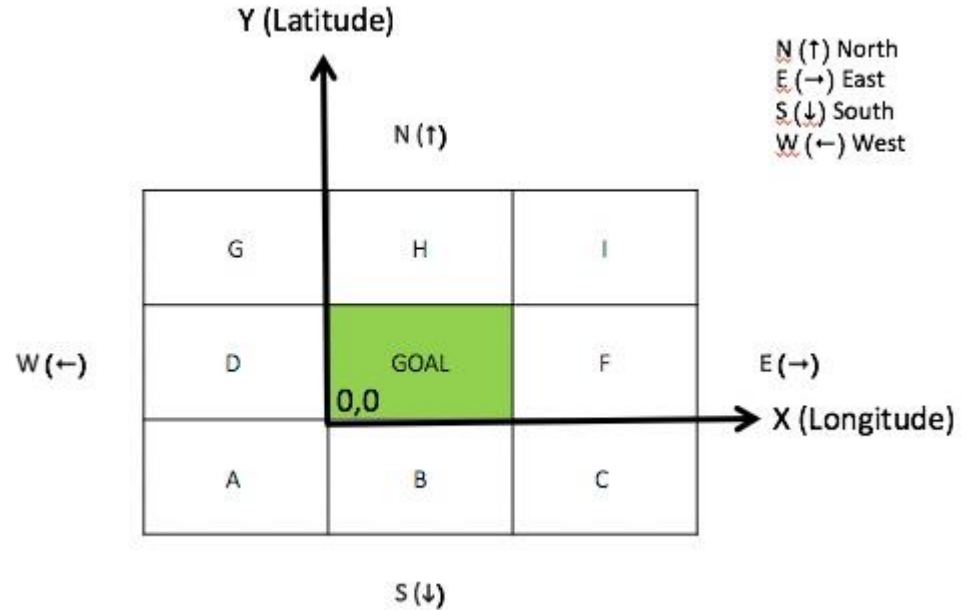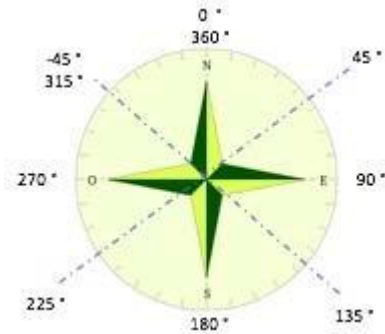
Longitude = asset_longitude – user_longitude
Latitude   = asset_latitude – user_latitude

Linguistic Variables and Linguistic Values

Longitude   :   [Negative, Zero, Positive]

Latitude   :   [Negative, Zero, Positive]

Direction   :   [North, East, South, West]

Movement   :   [Go Further, Stay]

Positioning Rule Base

Code in Positioning Diagram	Antecedents		Consequents	
	Δ Longitude (X)	Δ Latitude (Y)	Direction	Movement
A	Negative	Negative	North	Go Further
D	Negative	Zero	East	Go Further
G	Negative	Positive	East	Go Further
B	Zero	Negative	North	Go Further
GOAL	Zero	Zero	North	Stay
H	Zero	Positive	South	Go Further
C	Positive	Negative	West	Go Further
F	Positive	Zero	West	Go Further
I	Positive	Positive	South	Go Further

9 Fuzzy Rules

IF (**Longitude** = Negative) AND (**Latitude** = Negative) THEN (**Direction** = North) AND (**Movement** = Go Further)

IF (**Longitude** = Negative) AND (**Latitude** = Zero) THEN (**Direction** = East) AND (**Movement** = Go Further)

IF (**Longitude** = Negative) AND (**Latitude** = Positive) THEN (**Direction** = East) AND (**Movement** = Go Further)

IF (**Longitude** = Zero) AND (**Latitude** = Negative) THEN (**Direction** = North) AND (**Movement** = Go Further)

IF (**Longitude** = Zero) AND (**Latitude** = Zero) THEN (**Direction** = North) AND (**Movement** = Stay)

IF (**Longitude** = Zero) AND (**Latitude** = Positive) THEN (**Direction** = South) AND (**Movement** = Go Further)

IF (**Longitude** = Positive) AND (**Latitude** = Negative) THEN (**Direction** = West) AND (**Movement** = Go Further)
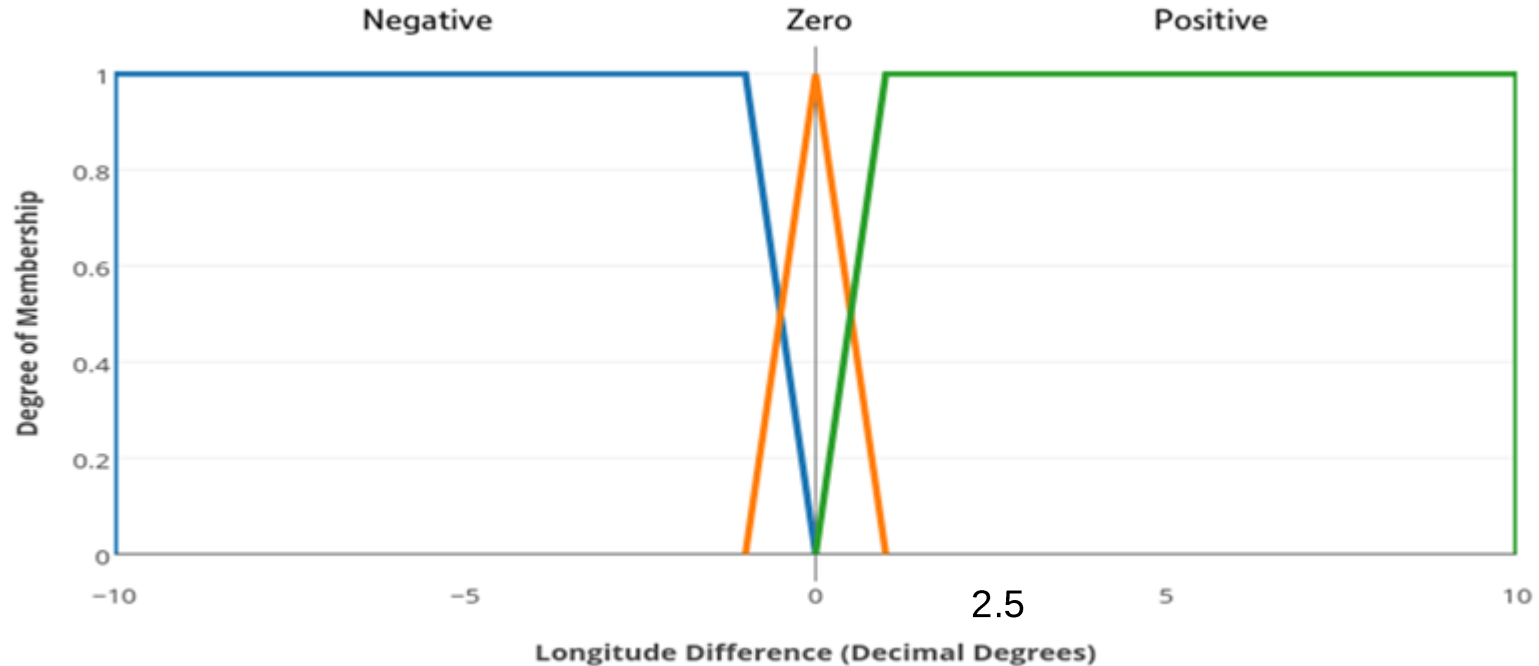
IF (**Longitude** = Positive) AND (**Latitude** = Zero) THEN (**Direction** = West) AND (**Movement** = Go Further)

IF (**Longitude** = Positive) AND (**Latitude** = Positive) THEN (**Direction** = South) AND (**Movement** = Go Further)
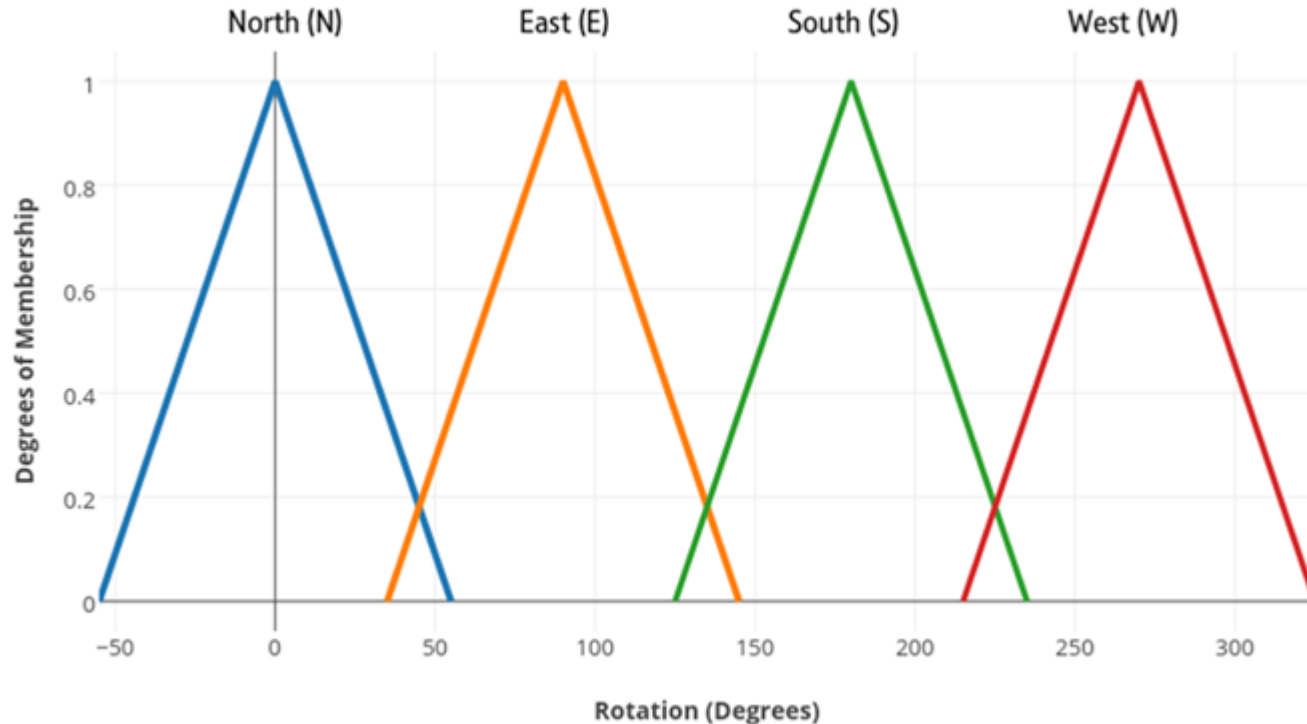
Membership Function : Antecedent :
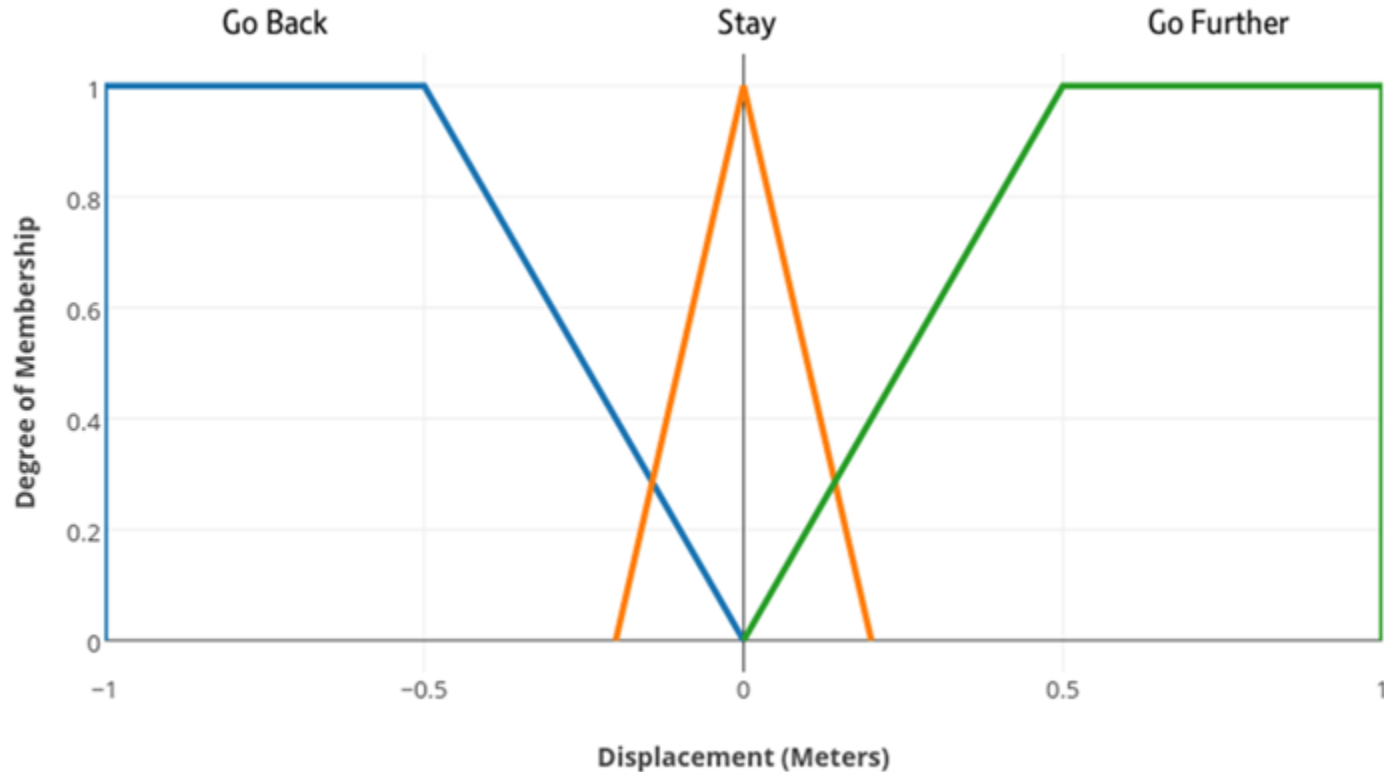## Latitude Difference
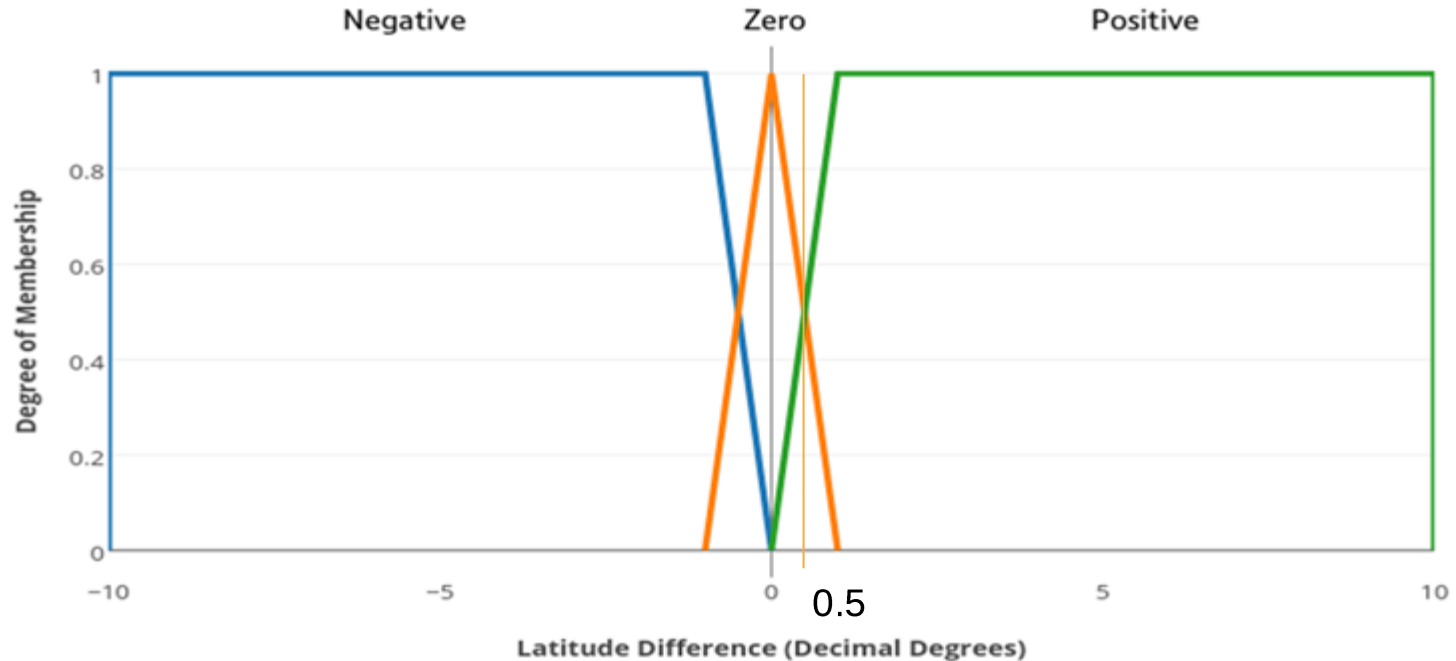
Membership Function : Antecedent : Longitude Difference

Membership Function : Consequent : Rotation

Membership Function : Consequent : Displacement

Defuzzification and Post Processing Output

- The result of inferrence engine is defuzzified into a crisp number using height defuzzification method.
- Difficult to interpret by a human, additional post processing step is required.
- Compare the previous value with the new value obtained by FLS.
- Previous direction : North, New value : South, the system suggests to 'Go Further' by 'Making U-Turn' assuming the natural human walking.

Condition	Human-understandable direction
If previous heading is the same as new heading	Keep Heading
If previous heading is directly opposite as new heading	Make a U-Turn
If previous heading is next on the left side of the new heading	Turn Right
If previous heading is next on the right side of the new heading	Turn Left

Experiments and Results

- 110 path explorations in an area of nearly 5000 square meter, locating the asset (underground cables).

- Locate the engineer in an initial coordinate, where after getting feedback from the system, he moved following the given instructions.

- The system is continously updated as soon as it detected a deference of the location.

An Asset position

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Experiments and Results

(a) Field engineer
(b) Mobile app
(c) View from HoloLens

(a)

(b)

(c)

Summary and Conclusion

- Proposed an innovative Augmented Reality system combined with fuzzy logic mechanisms to create a system able to direct engineers and technicians to an asset's location, targeting the issue of uncertainty generated by sensors and human error.

Thank you