Projection-Based Models for Capturing Human Concepts of Motions

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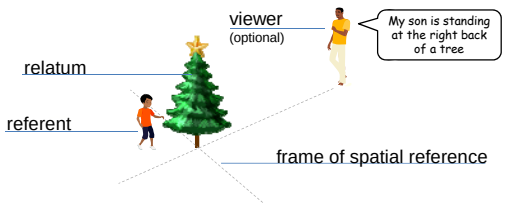
What are Projection-Based Models?

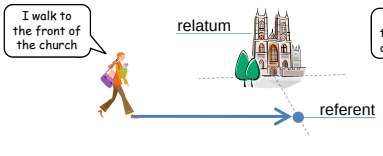
Projection-based models [1] are spatial models that projects **a frame of spatial reference** [2] onto a space, by which the arrangement of two or three spatial objects are distinguished



Projection-Based Models and Motion Concepts

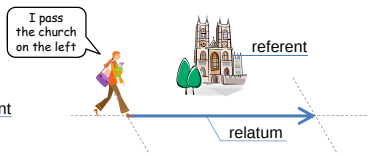
Two types of projection-based models are potentially useful for modeling human concepts/expressions of movement

Point-Referent Models



Goal-oriented motion concepts
go to the front/right/left of, go behind, go to the north of, …

DLine-Relatum Models



Path-centric motion concepts
pass … on the left/right, go along, go toward, go across, go into, …

Research Goal

To systematize the existing projection-based models and identify the missing models that are potentially useful for modeling motion concepts

In our perspective, this study consolidates a foundation of our project toward the natural dialogue-based interface of intelligent semi-autonomous wheelchairs

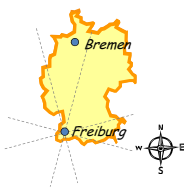
Systematization Criteria

1. Geometric types of the referent / relatum

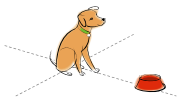
Point (P) | Directed Point (P_D) | Line (L) | Straight Directed Line (L_{SD}) | Region (R) | Directed Region (R_D)

2. Frame class distinguished by its orientation factor [2]

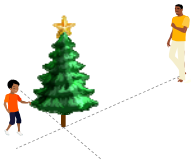
Absolute Frame



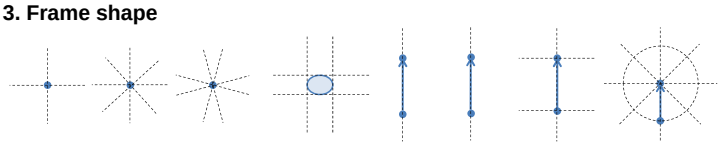
Intrinsic Frame



Relative Frame



3. Frame shape



Existing Projection-Based Models

Model	Frame Shape	Frame Class	Referent	Relatum	Viewer	Code Name
Single Cross [3]		relative	P	P	P	$\mathbf{PrP_{1\text{-}8}}$
Double Cross in [3]		relative	P	$P\times2$		$\mathbf{PrP_{1\text{-}8}^2}$
Double Cross in [4]		intrinsic	P	L_{SD}	–	$\mathbf{PiL_{SD\ 3\text{-}12}}$
Dipole Calculus [5, 6]		intrinsic	$L_{SD}\times2$		–	$\mathbf{L_{SD}iL_{SD\ 0\text{-}2}^2}$
Models of Cardinal Directions [7]		absolute	*Arbi-trary*	*Arbi-trary*	–	$\mathbf{AaA_{1\text{-}8}}$
Ternary Point Configuration Calculus (TPCC) [8]		relative	P	P	P	$\mathbf{PrP_{1\text{-}24}}$
Bipartite Arrangements [9]		intrinsic	L_{SD}	L_{SD}	–	$\mathbf{L_{SD}iL_{SD\ 3\text{-}12}}$
Star Calculus [10]		absolute	P	P	–	$\mathbf{PaP_{1\text{-}4n}}$
Oriented Point Relation Algebra (OPRA) [11]		intrinsic	$P_D\times2$		–	$\mathbf{P_DiP_{D\ 1\text{-}n}^2}$
Ego Orientation [12]		intrinsic	P	P_D	–	$\mathbf{PiP_{D\ 1\text{-}n}}$
Orientation Calculi [12]		intrinsic	P	L_{SD}	–	$\mathbf{PiL_{SD\ m\text{-}n}}$

For systematization, projection-models are given the code names:

$\mathbf{XyZ_{m\text{-}n}^{\ d}}$

- Referent
- Frame class
- Relatum
- Number of units that composes one relation
- Number of fields on/around the referent

What Models Are Not Yet Developed?

Point-Referent Models ($\mathbf{PyZ_{m\text{-}n}^{\ d}}$)

√ **PaP** √ **PaL** √ **PaR** (⊂ √ **AaA**)
√ **$\mathbf{PiP_D}$** √ **$\mathbf{PiL_{SD}}$** × **$\mathbf{PrR_D}$**
√ **PrP** × **PrL** × **PrR**

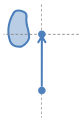
These three are potentially useful for capturing **goal-oriented motion concepts** when the landmark is linear or region-like (e.g., go to the front of the door, go behind the table)

DLine-Relatum Models ($\mathbf{XiL_{SDm\text{-}n}^{\ d}}$)

√ **$\mathbf{PiL_{SD}}$** × **$\mathbf{LiL_{SD}}$** (⊃ √ **$\mathbf{L_{SD}iL_{SD}}$**) × **$\mathbf{RiL_{SD}}$**

These two are potentially useful for capturing **path-centric motion concepts** when the landmark is linear or region-like (e.g., go toward the door, go across the rug)

Based on this idea, we are currently developing a series of models that belong to **$\mathbf{RiL_{SD}}$** and applying them to the modeling of a number of motion concepts [13]



References

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