Ontology-based Interpretation of Arrow Symbols for Visual Communication

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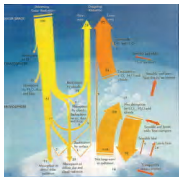
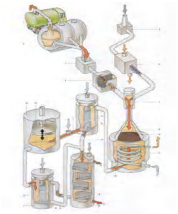
Motivation

Arrow symbols are ubiquitous in visual representations.

Arrow symbols are believed to facilitate the understanding of a spatio-dynamic process or mechanism.

However, since arrow symbols are polysemic, people actually have to interpret the *meaning* of arrow symbols.

For instance, in this figure, arrow symbols illustrate causality, decrease, and shift. How do we distinguish them unconsciously?

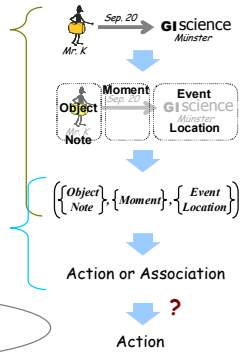
Research Goal

To study the mechanism of the interpretation of arrow symbols through modeling the interpretation process

- To gain an insight into the appropriate use of arrow symbols in visual representations
- To contribute the development of pen-based user interfaces

Related Work on Arrow Interpretations

1. Structures associated to individual arrow symbol are defined*1
2. The meanings of arrow symbols are categorized into four types: *action*, *property specification*, *annotation*, and *association**2
3. A method for deriving candidates for valid interpretation from the structural patterns is developed*2



The next question is how to narrow down these candidates

*1 Kurata and Egenhofer (2005) Semantics of Simple Arrow Diagrams. *Mental and External Diagrams, AAI Spring Symposium.*
*2 Kurata and Egenhofer (2006) Structure and Semantics of Arrow Diagrams. *COSIT'05.*

Necessity of Background Knowledge

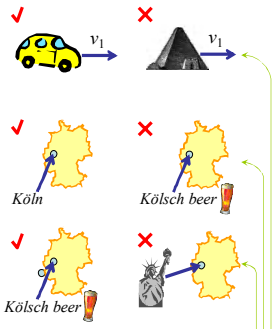
The following three figures have the same structural patterns—"*object* → *location*"—which correspond to *action* or *association*.

but only the first figure may capture *action* (i.e., a trip to Berlin), because among a car is movable, while a broken car, *Brandenburg Gate,* and *Berlin* are immovable.

These examples indicate that background knowledge about components' mobility is necessary for judging whether an arrow symbol really captures *action*.

Similarly, other types of semantics require components with the following characteristics:

- *Property specification* requires a component that may have a property related to orientation, such as moving speed
- *Annotation* requires a component that can be assigned the given label
- *Association* requires two associable components



Thus, an interpretation is detected invalid if the interpretation impose a certain characteristics on a component even though this component cannot have this characteristics.

In this way, making use of the knowledge on whether components may have the above characteristics, we can narrow down the candidates for valid interpretation

Then, how can we obtain such knowledge?

—*Ontology* is a potential source.

Ontology:
- A formal model of people's conceptualizations about the world
- Typically consists of
  - vocabularies,
  - properties and operations associated with each vocabulary
  - relations between the vocabularies
- Typically hierarchical

Ontology for Detecting Mobility

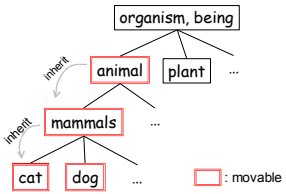
An ontology*3 is useful for deriving computationally, for instance, the mobility of a component.

*3 We used *WorldNet* (Fellbaum, 1998) as a sample ontology.

Case 1 Mobility is employed in the definition of an entity class

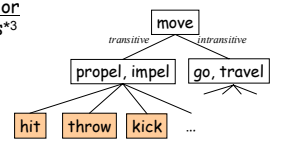
e.g., *Animal* ::= living organism characterized by voluntary movement*3

Case 2 Mobility is inherited from superclass (=parent)



Case 3 An entity has mobility if it has:
- an active operation *move* (in its intransitive sense) or one of its subclasses, or
- a passive operation *be moved* or one of its subclasses

e.g., *Ball* ::= a round object that is hit or thrown or kicked in games*3



In addition, the ontology is potentially useful for detecting:

- Direction-dependent mobility
  e.g., *elevator* ::= a lifting device consisting of a platform or cage that is raised and lowered mechanically*3

- Field-dependent mobility
  e.g., *vessel* ::= a craft designed for water transportation*3

What about the characteristics other than mobility?

Future Work

- To investigate **further use of ontologies** to derive the knowledge about the other characteristics of components, which is useful for detecting invalid interpretations of arrow symbols.
- To make **a guideline for appropriate use of arrow symbols** from a viewpoint of the mechanism that people interpret arrow symbols, which facilitates successful understanding of visual representations.