Semantics of Simple Arrow Diagrams

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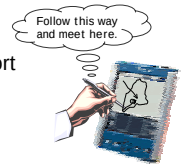
Why Arrows?

Arrows are a major component of diagrams, which are used multi-purposely to facilitate the communication of spatial and temporal knowledge.

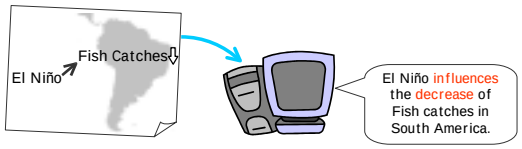
Pen-based interactions with computers are expected to support the use of diagrams with various meanings of arrows.



Current pen-based systems restrict the use of arrows to a small set of meanings or require their users to specify the meaning of every arrow.

Research Goal

To develop a computational method for interpreting the meaning of *arrow diagrams**.



* Arrow diagram := Arrow symbol + Arrow-related components

Approach

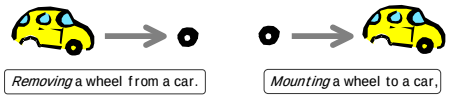
The appearance of the arrow symbol alone does not determine any meaning—the meaning is established when the arrow symbol originates from, traverses, or points to other elements in the diagram.

We focus on the *structure* that the arrow-related elements organizes around an arrow symbol.

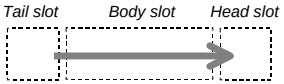
As a first step, this paper points out **three structural properties** of arrow diagrams that contribute to their interpretation.

1. Component Alignment

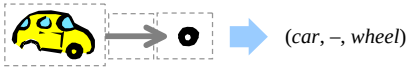
Different alignment of components leads to different interpretations of arrow diagrams.



Thus, to formalize the alignment of components, we introduce *three component slots* where the components are located.



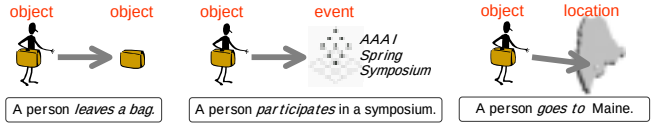
Then, an arrow diagram can be rewritten like:



2. Component Types

A component of an arrow diagram may be mentioned by an icon, a text, or a specific position in the background drawing. At a semantic level, however, the following *five types of components* are distinguished:

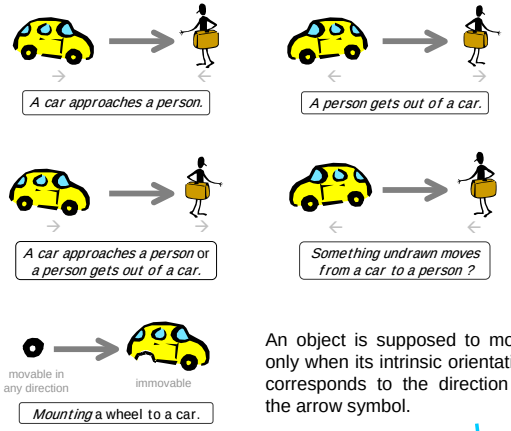
- An *object* takes an action.
- An *event* occurs in time, and is characterized by a set of changes.
- A *location* is a position in space (point or region).
- A *moment* is a position in time (instant or interval).
- A *note* is a description that supplements another component.



Different types of components lead to different types of interpretations, but arrow diagrams with identical alignments of component types often lead to the same class of interpretation.

3. Object's Orientations

An object expressed by an icon often has an *intrinsic orientation* toward which the object usually moves. This orientation is often a key for successful interpretation.



An object is supposed to move only when its intrinsic orientation corresponds to the direction of the arrow symbol.

Ongoing Work

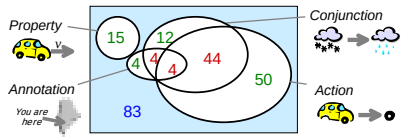
With the *three component slots* and the *five types of components*, we can distinguish 6^3 = 216 types of *simple arrow diagrams*.

simple arrow diagrams := (*c*, *c*, *c*)
c := – | *object* | *event* | *moment* | *location* | *note*

We investigated what semantics each type of arrow diagrams may illustrate, by classifying the arrow-related semantics into four classes (*property*, *annotation*, *conjunction*, and *action*) and considering the structural requirements for illustrating each class of semantics.

We found that:

- 83 types of arrow diagrams are meaningless.
- 15+4+12+50 = 81 types lead to a unique interpretation.
- 4+4+44 = 52 types are still ambiguous



Possible semantics of 216 types of simple arrow diagrams

For the 52 types of ambiguous arrow diagrams, we are now trying to determine the most reliable interpretation, making use of various clues in diagrams, such as the *intrinsic orientations* of objects.