ARROW SYMBOLS: THEORY FOR INTERPRETATION

By Yohei Kurata

Thesis Advisor: Max J. Egenhofer

An Abstract of the Thesis Presented
in Partial Fulfillment of the Requirements for the
Degree of Doctor of Philosophy
(in Spatial Information Science and Engineering)
May, 2007

People often sketch diagrams to facilitate their communications. If computers understand the diagrams, people can collaborate with computers more intuitively by sketching a diagram to explain their ideas and knowledge to computers. Arrow symbols are a frequent ingredient of such diagrams, because arrow symbols capture a large variety of semantics, as well as enable us to describe a dynamic process or mechanism in a static diagram. Due to the arrow's versatility, however, it remains a challenging problem to make computers distinguish the various semantic roles of arrow symbols. The solution to this problem is highly desirable for more effective and user-friendly pen-based systems. This thesis, therefore, develops a computational method for deducing the semantic roles of arrow symbols, called the *arrow semantic interpreter* (*ASI*).

The *ASI* emphasizes the structural patterns of arrow-containing diagrams, which have strong influence on their semantics. Since semantic roles of arrow symbols are assigned to individual arrow symbols and sometimes to the groups of arrow symbols, two types of the corresponding structures are proposed: the *individual structure* models the alignment of components around each arrow symbol and the *inter-arrow structure*

captures the formation of multiple arrow symbols. The semantic roles assigned to individual arrow symbols are classified into *orientation*, *behavioral description*, *annotation*, and *association*, and the patterns of individual structures that correspond to these four classes are identified. The result enables to derive the possible interpretations of each arrow symbol syntactically from its individual structure. On the other hand, for the diagrams with multiple arrow symbols, the patterns of their inter-arrow structures are exploited to detect both the groups of arrow symbols that jointly have certain semantic roles and the nesting relations between the arrow symbols.

An experiment in which the *ASI*'s prototype interprets the individual arrow symbols in the figures from a GIS textbook is conducted to examine the hypothesis that the computer-generated interpretations of arrow symbols match with their correct semantic roles. The result supports the hypothesis, showing that for 73% of the samples the prototype successfully deduces the possible interpretations that include the correct semantic roles.