UC Merced
Proceedings of the Annual Meeting of the Cognitive Science Society

Title
Construction of Acceptability Computation Algorithm for Projective Spatial Terms

Permalink
https://escholarship.org/uc/item/3820w46p

Journal
Proceedings of the Annual Meeting of the Cognitive Science Society, 29(29)

ISSN
1069-7977

Authors
Kojima, Takasugu
Kusumi, Takashi

Publication Date
2007

Peer reviewed

eScholarship.org Powered by the California Digital Library
University of California

Construction of Acceptability Computation Algorithm for Projective Spatial Terms

Takatsugu Kojima (kojima@cpsy.mbox.media.kyoto-u.ac.jp)
Takashi Kusumi (kusumi@mbox.kudpc.kyoto-u.ac.jp)
Graduate school of Education, Kyoto University
Yoshida-honmachi, Sakyo-ku, Kyoto, 606-8501, JAPAN

Keywords: spatial cognition and language understanding; projective spatial terms; computation

Introduction

This study proposes Acceptability Computation Algorithm for Projective spatial terms (ACAP). ACAP is based on the applicability computation algorithm for projective spatial terms contained in the situated language interpreter (SLI) model (Kelleher, 2003). Cognitive studies have validated the algorithm contained in the SLI, but three problems remain: (1) its distance-based deviation hypothesis has no empirical support; (2) it does not address the change in the acceptability distribution for a term with a reference object's rotation on a level plane in three-dimensional (3-D) space; and (3) it does not compute a prototypical point for a projective spatial term.

We have examined these problems by psychological experiment (Kojima & Kusumi, 2006a, 2006b, in press). Our results demonstrate (1) the empirical validity of the introduction of the distance-based deviation into the acceptability computation of projective spatial terms; (2) the characteristics of the acceptability distribution change with a reference object's rotation on a level plane in 3-D space; and (3) a method to compute a prototypical point.

Parameters

ACAP modifies and extends the algorithm in SLI, based on our experimental results. The new factors are the rotation module (R module) and the prototypical-point module (P module). R module accommodates the acceptability distribution on a spatial template (Logan & Sadler, 1996) to the rotation of a reference object in both 2-D and 3-D space. P module calculates the location of a prototypical point for a projective spatial term in a given situation. It enables ACAP to be applicable to different projective spatial terms in different languages.

Figure 1 shows basic parameters of ACAP on a spatial template. The square is the center of a reference object. The smaller circle is the center of a located object in location i. The larger circle is the prototypical point p in a given scene. The vertical line is a base axis for a projective spatial term. θ_i is an angle between the base axis and a vector rooted at the center of the reference object to the center of the located object. β is the maximum angle of the angular deviation (usually set to 90º). The diagonal line is the boundary of the area affected by the rating parameter g. ε is the angle between the boundary of the affected area and the base axis ($\varepsilon \leq \beta$). d_i is the distance between the prototypical point and the located object. γ is the maximum distance on the given spatial template. R module controls g and ε. P module controls p.

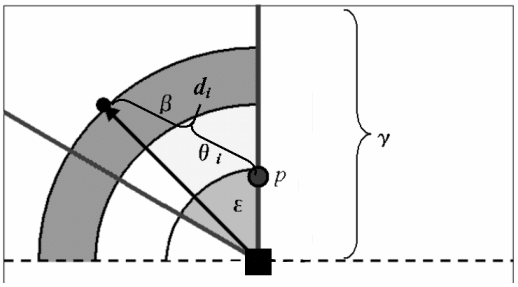


Figure 1: Parameters in ACAP.

Algorithm

An acceptability ψ_i in location i for a projective spatial term is computed in ACAP as below.

$$r_i = \begin{cases} g \cdot \lceil \sin\theta_i \rceil & (0 < \theta_i \leq \varepsilon) \\ 1 & (\theta_i = 0\ ,\ \theta_i > \varepsilon) \end{cases} \qquad \delta_i = \begin{cases} 1 - \dfrac{d_i}{\gamma} & (d_i \leq \gamma) \\ 0 & (d_i > \gamma) \end{cases}$$

$$\alpha_i = \begin{cases} \left(1 - \dfrac{\theta_i}{\beta}\right) \cdot r_i & (\theta_i \leq \beta) \\ 1 & \left(\left(1 - \dfrac{\theta_i}{\beta}\right) \cdot r_i > 1\right) \\ 0 & (\theta_i > \beta) \end{cases} \qquad \psi_i = \frac{\alpha_i \cdot \delta_i}{\rho}$$

References

Kelleher, J. (2003). *A Perceptually Based Computational Framework for the Interpretation of Spatial Language.* PhD thesis, Dublin City University, Dublin, Ireland.

Kojima, T. & Kusumi, T. (2006a). The effect of a reference object's orientation on the apprehension of spatial terms. *Cognitive Processing, 7,* 140-142.

Kojima, T. & Kusumi, T. (2006b). The effect of the extra object on the linguistic apprehension of spatial relationship between two objects. *Spatial Cognition and Computation, 6,* 145-160.

Kojima, T. & Kusumi, T. (in press). Computing positions indicated by spatial terms in three-dimensional space. *Psychologia.*

Logan, G. D., & Sadler, D. D. (1996). A computational analysis of the apprehension of spatial relations. In P. Bloom, M.A. Peterson, L. Nadel, & M. Garrett (Eds.), *Language and space* (pp.493-529). Cambridge, MA: MIT Press.