Chapter 6
Visual Perception in Image Analysis*
Digital Image Content via Tolerance Near Sets

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Abstract. This chapter considers how visual perception can be used to advantage in image analysis. The key to the solution to this problem was first pointed out by J.H. Poincaré in 1893 in his representation of the results of G.T. Fechner’s 1860 psychophysics experiments with sensation sensitivity in lifting small weights. The focus of Fechner’s experiments was on sensation sensitivity. By contrast, the focus of Poincaré rendition of Fechner’s experiments was on determining sets of similar sensations that serve as a model for a physical continuum. In what he later called a representative space (aka, tolerance space), Poincaré informally discerned tolerance relations in determining tolerance classes containing perceptually indistinguishable sensations. A formal view of tolerance spaces was first introduced by E.C. Zeeman in 1962 (nearly 70 years after Poincaré’s work on representative spaces). Unlike Poincaré, Zeeman focused on visual acuity in formulating the idea of a tolerance space. By defining a tolerance relation, one provides a basis for a rigorous study of resemblance between perceptual objects such as digital images or observed

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* Many thanks to Som Naimpally, Sheela Ramanna, Andrzej Skowron, Jarek Stepaniuk, Amir H. Meghdadi, Christopher Henry, Homa Fashandi, Shabnam Shahfar, and Piotr Wasilewski for the suggestions and insights concerning topics in this paper. I also want to Christopher Henry for the work he has done in putting together the NEAR system, a complete implementation of near sets tailored to the needs of image analysis that is reported in this chapter. This research has been supported by the Natural Sciences & Engineering Research Council of Canada, i.e., Conseil de recherches en sciences naturelles et en génie du Canada (NSERC) grant 185986, Manitoba Centre of Excellence Fund (MCEF) grant, and the Canadian Arthritis Network grant SRI-BIO-05.
behaviour patterns of collections of social robots. Eventually, the study of the resemblance of disjoint sets by Z. Pawlak and J.F. Peters, starting in 2002, led to the discovery of a formal basis for measuring the degree of nearness between distinct tolerance spaces. The main contribution of this paper is the introduction of a form of perceptual image analysis in terms of a methodology for determining the resemblance between pairs of visual tolerance spaces defined within the context of digital images.

**Keywords:** Image correspondence, metric space, nearness, near sets, perception, perceptual image analysis, resemblance, tolerance space.

1 Introduction

This chapter considers how visual perception can be used to solve image analysis problems such as discerning the extent of correspondence between images. The solution to the image correspondence utilizes image matching strategies to establish affinities between two or more images. This is one of the central tasks in photogrammetry and computer vision. Recently, it has been shown that tolerance near sets can be used in a perception-based approach to discovering correspondences between images (see, e.g., [2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14]). Disjoint sets that resemble each other are called near sets [15]. The study of near sets is directly related to more recent work on similarity, tolerance, covering systems, and resemblance [16, 17, 18] and a tolerance space view of what we see [3].

![Fig. 1 Sample Image Coverings Determined by Tolerance Relation $\approx_{gr, \varepsilon}$; see (1)](image)

2 Related Works

Work on a basis for near sets began in 2002, motivated by image analysis and inspired by a study of the perception of the nearness of physical objects carried out in cooperation with Zdzisław Pawlak in [19]. This initial work led to the introduction of near sets [20], elaborated in [21, 13]. The introduction of tolerance near sets leads to a perception-based approach to discovering resemblances between digital images. This approach to the study of perceptual resemblances also leads to the