Comparing Images with Distance Functions based on Attribute Interaction

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\section*{ABSTRACT}
This paper presents two new families of distance functions for image comparison through their feature vectors. These families concern with the effects of the interaction of attributes when two images are compared. Experiments were executed in order to corroborate the effectiveness of the new functions, leading to very promising results.

\section*{Categories and Subject Descriptors}
I.4.7 [\textit{Image Processing and Computer Vision}]: Feature measurement -- feature representation.
H.3.1 [\textit{Information Storage and Retrieval}]: Content Analysis and Indexing -- indexing methods.

\section*{Keywords}
Content-based retrieval, distance function.

\section*{1. INTRODUCTION}
Content-based Image Retrieval (CBIR) techniques [3] use a set of image processing algorithms to automatically extract relevant intrinsic visual features of images, such as color, shape and texture, and the feature vectors are then used to similarity-based retrieval of them. Similarity queries executed over the pictorial content of the image deal much more with the inherent information of the data than when executed over a textual description associated to them [4]. After defining a specific application context for the techniques, an important challenge is to define feature vectors that can: (a) discriminate the image content; (b) accept a similarity measure (distance function), and (c) act as the basis of an index structure to manage the image collection during querying process.

To perform an effective similarity comparison between images, it is crucial to choose a suitable distance function. Several distance functions have been proposed in literature, usually applied to specific applications or contexts [1].

\section*{2. METHOD}
Environment, context, application, purpose and nature of data are some variables that determine what features will be chosen to represent images for similarity retrieval tasks. Different descriptors can be used to compose the feature vectors that represent images. These vectors usually enclose several attributes related to one or more than one of these descriptors. An important question to be considered when comparing two images is: how do these features affect the human perception of similarity when they vary together? In other words, if images A and B present a high difference of only one attribute and images A and C present smaller differences on more than one attribute, what image, B or C, will be considered more similar to A? What is the effect of attribute variations on the human judgment of similarity?

Our objective is to answer this question, for a specific context or purpose, through the definition of families of distance functions (Attribute Interaction Distances - AID) that allow the user to set parameters and adjust the influence of attributes interaction and, hence, get closer to the human perception.

We propose two distance function families: Weak Attribute Interaction Distances (WAID) and Strong Attribute Interaction Distances (SAID). Both are polynomials of degree 2 that define the geometric place of objects that have the same distance to a reference one. WAID "brings closer" the objects that present high proportion of difference, while SAID "keeps far" these objects, as can be seen in Figure 1. In this graph, all points on the WAID curve are at the distance \( d_1 \) from Q, while all points on the SAID curve are at the distance \( d_2 \) from Q. On these curves, the distance of one point from Q increases or decreases in quadratic order in relation to the proximity of this point to the identity line. Taking point C2, if we choose to work with WAID, its distance from Q (d1) will be lower than if we choose to work with SAID (d2). Comparing the distances from C2 to Q and from C3 to Q, we can see that if we choose WAID, then distance (Q, C2) will be smaller than distance (Q, C3), otherwise, if we choose SAID, then distance (Q, C2) will be bigger than distance (Q, C3).

In order to quantify and control the effect of attribute interaction, we define a parameter \( n \) that represents the degree of interaction and determines the elongation of the curves. This leads to a family of curves for WAID and another for SAID. Figure 2 shows some curves for family SAID.
SAID and WAID families can compose with Lp family to cover the whole feature space, as shown in Figure 3. The superior limit of SAID is $L_1$ (SAID with $n=2$) and the inferior limit of WAID is $L_\infty$ (WAID with $n=1$).

### 3. RESULTS

A set of 30 images was gathered. These images consist of regions of interest (ROIs) extracted from medical images of Magnetic Resonance, Computerized Tomography and Mammography from the Clinical Hospital at University of Sao Paulo – Ribeirão Preto, Brazil. Five radiologists (R1, R2, R3, R4, e R5) were asked to organize the images in order of similarity with a reference one, comparing the texture presented by the images. A tool extracting texture descriptors and executing $k$-nearest neighbor queries has processed this image set. The texture descriptors that were chosen to represent images were uniformity and homogeneity, extracted from their co-occurrence matrices. A detailed description of them is presented in [2]. K-nearest neighbor queries were executed in this image set, for each distance function of families AID and Lp. Each radiologist sequence was then compared with the results of each distance function. Precision was calculated as the degree of accordance between each radiologist sequence and each distance function sequence.

### 4. DISCUSSION

From the analysis of the curves in Figure 4, we can see that the distance function that produced results closer to the radiologists’ sequences was SAID. It indicates that this kind of context is characterized by strong attribute interaction. For each different context, an experiment like that can be done, allowing us to identify the distance function that is best suited to the context.

### 5. REFERENCES


