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Universal metric space of dimension n and its application in clustering

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Abstract

In this paper we introduce an n-dimensional ($n \geq 2$) distance metric over a given space to define a universal metric space. This distance metric measures how separated every n points of the space. One goal of this paper suggest a possible application of this theory is clustering.

Keywords: Universal metric spaces, G-metric spaces, Clustering
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1 Introduction

The theory of metric spaces plays a major role in different fields of mathematics and applied sciences. Gähler [1] introduced the notion of a 2-metric space. In 1992, Dhage [2] proposed the notion of a $D-$metric space. They introduced a new class of generalized metric spaces called G-metric spaces. In 2014, Dr. Dehghan Nezhad proposed the notion of a metric spaces called U_n-metric spaces as follows.

2 Universal metric spaces of dimension n

For $n \geq 2$, let X^n denotes the cartesian product $X \times \ldots \times X$. We begin with the following definition.

Definition 2.1. Let X be a non-empty set. Let $U : X^n \longrightarrow \mathbb{R}^+$ be a function that satisfies the following conditions:

(U1) $U(x_1, \ldots, x_n) = 0$ if $x_1 = \ldots = x_n$.

(U2) $U(x_1, \ldots, x_n) > 0$ for all $x_1, ..., x_n$ with $x_i \neq x_j$, for some $i, j \in \{1, ..., n\}$.

(U3) $U(x_1, \ldots, x_n) = U_n(x_{\pi_1}, \ldots, x_{\pi_n})$, for every permutation $(\pi_{(1)}, ..., \pi_{(n)})$ of $(1, 2, ..., n)$.

(U4) $U(x_1, x_2, \ldots, x_{n-1}, x_{n-1}) \leq U(x_1, x_2, \ldots, x_{n-1}, x_n)$ for all $x_1, \ldots, x_n \in X$.

(U5) $U(x_1, x_2, \ldots, x_n) \leq c(U(x_1, a, ..., a) + U(a, x_2, ..., x_n))$, for all $x_1, \ldots, x_n, a \in X,\ 0 < c \leq 1$.

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