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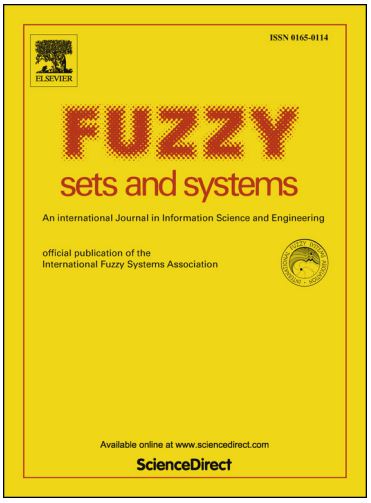

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ACCEPTED MANUSCRIPT

Fuzzy functional dependencies: a comparative survey

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Abstract. Similarity search and related issues are current topic in databases. Over the last ten years more then 6500 papers dealing with similarity in databases were published according to Web of Science. The rising in the number of articles in the recent years shows that the research in this direction is still in its early stage. From the wide range of topics related with similarities in databases, one received a considerable attention already, namely functional dependencies which take similarities into account. Our main concern in this paper is to review and critically examine the existing work on this topic.
Keywords: Functional dependencies, Fuzzy functional dependencies, Relational model, Fuzzy relational model, Fuzzy database, Similarity relations, Similarity-based functional dependencies, Residuated lattice, Fuzzy logic

1 Introduction

More than one hundred papers dealing with functional dependencies (FDs) over domain with similarities can be found in the literature, and many of them contain interesting generalizations regarding the original notion of functional dependency (FD). In our opinion, the wide range of approaches are worthy of an exhaustive review and a comparison of the most significant ones. Often the name "fuzzy functional dependencies" is used for various extensions of FDs which we think is unfortunate for several reasons. One of them is that the name is too broad and concerns various aspects (e.g. even in the ordinary relational model, i.e. without similarity, some things may be considered fuzzy, i.e. a matter of degree). Furthermore, there is no agreement among researchers what the terms "fuzzy database" and "fuzzy functional dependencies" really mean. For example in [97] the term fuzzy database is used for a collection of relations, where each relation is understood as an ordinary subset of the Cartesian product of domains, where domains are collections of possibility distributions. Contrary to that, in [80] the fuzzy relational data model is used for a collection of fuzzy relations, i.e. fuzzy subsets of the Cartesian product of domains. Since the name "fuzzy functional dependency" is usually used for functional dependencies defined within "fuzzy relational model", it is not clear what "fuzzy functional dependency" really means. Moreover, although many definitions of so-called fuzzy functional dependencies extend the classical one, the dependency usually remains crisp in the sense that either a given relation satisfies the dependency or it does not. In this sense the term fuzzy functional dependency is inadequate, even though we understand that it may be seen as a convenient shorthand. We will therefore use the term generalized functional dependency (GFD) and generalized relational model (GRM) to prevent misunderstanding.

It is not surprising that among other topics related to various generalizations of the relational model, functional dependencies are one of the most studied. Functional dependencies are part of Codd's relational model from its very beginnings and are an essential notion for database design, where they serve as an important tool for redundancy elimination and normalization. The interpretation of an ordinary functional dependency $A \Rightarrow B$ in a given data table $\mathcal{D}$ is the following: if any two tuples have the same values on all attributes from A, then they have the same values on all attributes from B. We say that A determines B or B is functionally dependent on A.

We specifically intend to concentrate on FD over domains with similarities and the directly related issues. What does "FD over domains with similarities" mean? We consider it reasonable

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