

# Fuzzy clustering algorithms based on the maximum likelihood principle

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*Abstract:* A number of hard clustering algorithms have been shown to be derivable from the maximum likelihood principle. The only corresponding fuzzy algorithms are the well known fuzzy  $k$ -means or fuzzy ISODATA of Dunn and its generalizations by Bezdek and by Gustafson and Kessel. The authors show how to generate two other fuzzy algorithms which are the analogues of known hard algorithms: the minimization of the fuzzy determinant and of the product of fuzzy determinants.

By comparison between the hard and fuzzy methods it appears that the latter yield more often the global optimum, rather than merely a local optimum. This result and the comparison between the different algorithms, together with their specific domains of application, are illustrated by a few numerical examples.

*Keywords:* Fuzziness; cluster analysis; algorithm; maximum likelihood.

## 1. Introduction

In situations where a large amount of data has to be analysed, it is useful to look for clusters first. Many clustering methods are based on the search for centroids or representative objects around which all observations will be clustered on a minimum distance basis. However, this approach tends to identify only hyper-spherical clusters with equal diameters.

To search for clusters of different shapes, Scott and Symons [12] proposed a variety of methods based on the maximum likelihood principle, leading to the minimization of the product of the determinants of the scatter matrices. The minimum variance criterion of Ball and Hall [1] is a particular case of this approach. Moreover, the link between this last method and fuzzy  $k$ -means was established by Dunn [6].

This paper proposes a generalization of some of the hard maximum likelihood clustering methods to the fuzzy approach, leading to some new fuzzy clustering algorithms. In particular, a fuzzy version of the minimum determinant [7] and of the minimum product of determinants [12] is derived. Finally, some properties and features of the different methods are discussed and compared with each other.

# Fuzzy Algorithms

**Michael Hoelscher**



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## **Table of Contents Fuzzy Algorithms**

1. Understanding the eBook Fuzzy Algorithms
  - The Rise of Digital Reading Fuzzy Algorithms
  - Advantages of eBooks Over Traditional Books
2. Identifying Fuzzy Algorithms
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an Fuzzy Algorithms
  - User-Friendly Interface
4. Exploring eBook Recommendations from Fuzzy Algorithms
  - Personalized Recommendations

- Fuzzy Algorithms User Reviews and Ratings
- Fuzzy Algorithms and Bestseller Lists
- 5. Accessing Fuzzy Algorithms Free and Paid eBooks
  - Fuzzy Algorithms Public Domain eBooks
  - Fuzzy Algorithms eBook Subscription Services
  - Fuzzy Algorithms Budget-Friendly Options
- 6. Navigating Fuzzy Algorithms eBook Formats
  - ePub, PDF, MOBI, and More
  - Fuzzy Algorithms Compatibility with Devices
  - Fuzzy Algorithms Enhanced eBook Features
- 7. Enhancing Your Reading Experience
  - Adjustable Fonts and Text Sizes of Fuzzy Algorithms
  - Highlighting and Note-Taking Fuzzy Algorithms
  - Interactive Elements Fuzzy Algorithms
- 8. Staying Engaged with Fuzzy Algorithms
  - Joining Online Reading Communities
  - Participating in Virtual Book Clubs
  - Following Authors and Publishers Fuzzy Algorithms
- 9. Balancing eBooks and Physical Books Fuzzy Algorithms
  - Benefits of a Digital Library
  - Creating a Diverse Reading Collection Fuzzy Algorithms
- 10. Overcoming Reading Challenges
  - Dealing with Digital Eye Strain
  - Minimizing Distractions
  - Managing Screen Time
- 11. Cultivating a Reading Routine Fuzzy Algorithms
  - Setting Reading Goals Fuzzy Algorithms
  - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Fuzzy Algorithms
  - Fact-Checking eBook Content of Fuzzy Algorithms

- Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
  - Utilizing eBooks for Skill Development
  - Exploring Educational eBooks
- 14. Embracing eBook Trends
  - Integration of Multimedia Elements
  - Interactive and Gamified eBooks

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