

2. Streszczenie w języku angielskim

Research activities focus on the development of advanced artificial intelligence methods for the effective processing of uncertain, incomplete, and distributed data while preserving user privacy. The primary research direction involves the advancement of **federated learning** techniques supported by **interval-valued fuzzy set theory** and advanced information aggregation methods.

A significant contribution of this research is the development of novel aggregation methods for local models in federated environments using the **Choquet and Sugeno integrals**, as well as weighting mechanisms based on **entropy measures** and the performance of local models. The proposed approaches enhance the robustness of federated systems to data heterogeneity, class imbalance, and uncertainty commonly encountered in real-world applications.

Another important research direction concerns the representation and management of uncertainty through **interval-valued fuzzy sets (IVFSs)**. In particular, novel logistic regression models with interval-valued weights and innovative learning mechanisms have been proposed to provide a more accurate representation of variability and imprecision in medical data.

A substantial part of the research is devoted to the development of **interpretable decision support systems** based on fuzzy rules. Hybrid models integrating expert knowledge, rule induction techniques, and federated learning have been designed and successfully applied to tasks such as **elderly fall detection** and **medical diagnosis**, combining explainability with privacy preservation.

The conducted research has a strong application-oriented character and addresses problems in **breast cancer diagnosis, medical data analysis, elderly monitoring systems**, and other domains where high predictive performance, model interpretability, and data privacy must be ensured simultaneously. Overall, the body of work constitutes a coherent research program integrating artificial intelligence, fuzzy logic, uncertainty theory, and federated learning to develop modern, secure, and trustworthy decision support systems.

The research can be categorized into the following main research directions:

- **Federated Learning**, with particular emphasis on privacy preservation and collaborative learning among multiple distributed entities without sharing raw data.
- **Uncertainty modeling using Interval-Valued Fuzzy Sets (IVFSs)** and their application to machine learning algorithms.

- **Novel aggregation methods for federated models**, including the use of the **Choquet integral**, **Sugeno integral**, and **entropy-based weighting schemes** to improve the quality and robustness of global models.
- **Development of learning methods for incomplete, imbalanced, and uncertain datasets**, with a particular focus on medical applications.
- **Design of interpretable fuzzy inference and rule-based systems** integrated with federated learning techniques for decision support.
- **Applications of artificial intelligence in medical diagnostics**, especially in **breast cancer diagnosis**, as well as **human fall detection and elderly monitoring systems**.