# Soft Computing: Theory Innovations and Problem-Solving Benefits Minitrack

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Soft computing encompasses a range of established techniques, including fuzzy logic, neuro-computing, probabilistic reasoning, and evolutionary computation. By capitalizing on the distinct advantages of each technique, these methodologies can collaborate effectively to tackle myriad complex real-world challenges. Such problems often elude conventional methods, which typically fail to deliver low-cost, analytical, and comprehensive solutions. Historically, computational approaches have been confined to the modeling and analysis of relatively simple systems. However, the growing complexity of systems in fields such as biology, health, economics, and the digital world has rendered conventional mathematical and analytical methods insufficient. Consequently, advancements in soft computing techniques have emerged as essential for the analysis and modeling of more complex systems. Soft computing effectively addresses challenges associated with imprecision, uncertainty, partial truth, and approximation, thereby facilitating enhanced computability, robustness, and cost-effectiveness in solutions. This methodology is particularly adept at managing large-scale, rapid, and unstructured changes intrinsic to the digital environment.

This minitrack is designed to engage researchers with an interest in the outlined research area. We welcome submissions that encompass not only theoretical advancements but also practical applications that illustrate the problem-solving advantages of utilizing soft computing-based methodologies. Relevant fields of interest include the digital world, digital coaching, digital health, digital economy, cognitive computing, and the design and management of digital services and service systems. We invite submissions that employ either analysis-oriented or systems-oriented methodologies. Submissions may focus on experimental or empirical research. We particularly encourage innovative studies that utilize explainable methods, integrating advanced theoretical results with rigorous empirical verification or effective empirical problem-solving, planning, and decision-making in conjunction with innovative theory development. A fundamental aspect of all submissions is the construction and application of models based on soft computing principles.

The first paper of this minitrack, “Enhancing Group Decision-Making Through Large Language Models for Semantic Filtering of Expert Opinions”, introduces a group decision-making framework that uses DeepSeek LLM (Large Language Model) to semantically analyze and filter expert commentary, removing remarks that could negatively influence others. Unlike traditional sentiment analysis based on fixed lexical rules, the LLM identifies subtle features such as tone, context, and implied meaning, allowing for more accurate extraction of expert preferences. The processed inputs are the aggregated to form a consensus that accurately reflects collective judgment, improving interpretability, fairness, and reliability in complex environments. This approach moves beyond standard sentiment analysis by using the LLM for both interpretation and active semantic filtering.

The second paper of this minitrack, “Federated Learning for Brain Tumor Classification from MRI: A Comparison of MLP and ConvNeXt Approaches under IID and Non-IID Data Scenarios”, compares two neural network approaches for brain tumor classification using magnetic resonance imaging within a federated learning framework. Both models process regions of interest (ROIs) extracted from brain MRI scans. The first approach utilizes a lightweight multilayer perceptron (MLP) that classifies ROIs based on extracted radiomic features. The second approach employs a deep learning model based on the ConvNeXt architecture, which classifies directly from ROI images. Two experimental scenarios are evaluated: a balanced (independent and identically distributed, IID) and an unbalanced (non-IID) distribution of data among federated clients. The results indicate that the radiomics-based MLP achieves performance comparable to the more complex ConvNeXt model while requiring substantially fewer computational resources. Additionally, federated learning consistently surpasses isolated local training, particularly under non-IID conditions, highlighting its potential for clinical application.

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The third paper of this minitrack, “Embracing Uncertainty in Human Activity Recognition: A Fuzzy Logic Framework for Interpretable and Context-aware Reasoning”, introduces a theoretical framework that incorporates fuzzy reasoning across the Human Activity Recognition (HAR) pipeline, including sensor abstraction, context modeling, interpretable activity inference, and natural language explanations. Uncertainty is conceptualized as a representational and inferential resource rather than a constraint. This approach enables systems to more accurately reflect the complexity of human behavior and the requirements of human-centered artificial intelligence. The framework is modular, extensible, and designed to promote transparency. It is intended for long-term deployment in smart environments, particularly in fields such as elderly care, remote monitoring, and assistive technologies. This work establishes a structured foundation for the development of next-generation HAR systems that advance beyond black-box classification and facilitate ethical, explainable, and context-sensitive activity recognition.

The fourth paper of this minitrack, “Emotions in Collective Risk Dilemmas Using Fuzzy Linguistic Rules”, proposes how to model emotions in climate change policies through evolutionary game theory (i.e., collective risk dilemmas) using fuzzy linguistic rules. The authors first study evolutionary game theory models for exploring climate change policies and decisions to enhance cooperation between the policy players. Using computational agent-based simulations, the authors build a framework where they incorporate and extend evolutionary game models with players' emotions in the game dynamics. These emotions, modeled by fuzzy linguistic rules, are a way for players to reconsider their strategies when playing the game. Results show how these rules representing emotions can better control defection in the collective-risk dilemmas while modeling a more realistic way of dealing with players' features.

Finally, the fifth paper of this minitrack, “Analyzing Protocols of Information Granularity Allocation to Compute Missing Values in Intuitionistic Reciprocal Preference Relations”, assesses the effectiveness of existing protocols for allocating information granularity, namely a symmetric and uniform allocation, an asymmetric but uniform allocation, a symmetric but non-uniform allocation, an asymmetric and non-uniform allocation, in the estimation of missing values in incomplete intuitionistic reciprocal preference relations. Numerical tests are included to demonstrate the efficacy of the protocols.