

Intelligent Decision Support Systems for Nephrology: Integration of Expert Knowledge and Machine Learning for Automated Risk Classification and Treatment Optimization

Abstract

The complexity of nephrology diagnosis and treatment presents significant challenges in clinical decision-making, particularly for conditions like Focal Segmental Glomerulosclerosis (FSGS) and Idiopathic Membranous Nephropathy (IMN).

This paper presents a comprehensive synthesis of two advanced expert systems that integrate expert knowledge with machine learning for automated risk classification and treatment optimization. We describe the FSGS Nephro Decision Support System (FNDSS) and an automated IMN risk classification system, both employing ensemble learning methods including Random Forest, LightGBM, and Gradient Boosting algorithms. Clinical validation with 127 FSGS patients (2012-2023) revealed diagnostic and treatment discrepancies in 17 cases (13.4%), while the IMN system achieved 100% accuracy in risk group assessment across 56 patients. Both systems demonstrated high technical performance (precision 0.91-0.98) and identified areas for improved protocol adherence in clinical practice. Further multi-center validation and automated data integration are planned to confirm model generalizability and optimize real-world deployment.