Project Research : Researches on accurate pattern recognition techniques

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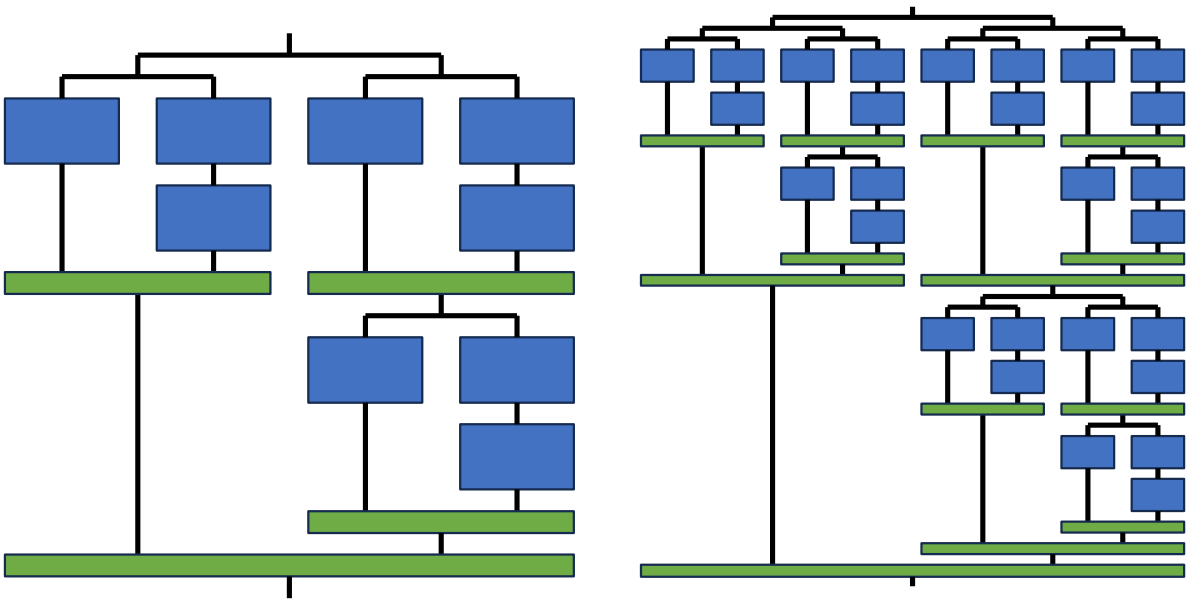
Research on enabling machines to recognize various patterns has been conducted since the 1950s and has evolved based on the application of probability and statistics to measure the proximity, distance, and similarity between patterns. As for the practical applications of pattern recognition technology, research in biometrics—which focuses on information specific to individuals—and research on the recognition of the external environment for autonomous driving, both of which began around 1990, have been put into practical use following their implementation in society. However, human pattern recognition capabilities exist at a level that machines cannot achieve, and elucidating the human recognition system is a field of study of significant scientific and engineering importance. This research aims to establish a unique pattern recognition technology in order to derive methodologies that bring us even a little closer to the level of human visual information processing. In addition to basic research, the project will address applications such as biometric personal authentication, medical image processing, remote sensing image analysis, texture analysis, and autonomous driving, with the goal of simulating the recognition system on a computer, from feature extraction through recognition.

To achieve this target, we aim to establish high-precision pattern recognition algorithms based on deep learning and, as an application of these algorithms, to develop image recognition systems capable of processing various types of image media, including still images, video, 3D point clouds, and remote sensing images.

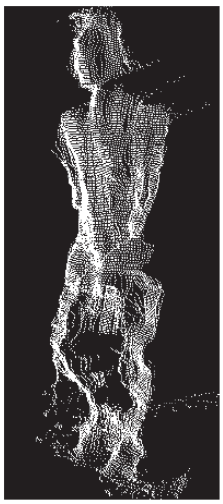
(1) As part of our basic research on pattern recognition, we have been studying methodologies for structural transformation from image information to fractal representations. By applying self-similar fractal structures to neural networks and introducing a mechanism for information propagation using the wavelet transform, we have established a high-precision, high-speed classification method. The paper in part of this work is appeared in the journal Neural Networks, entitled FracNeXt: Enhancing visual representation learning in sequence models with fractal wavelets, in June 2026.



An example of self-similar Fractal network structure

(2) As an application of pattern recognition, we developed a gait recognition framework based on 3D human joint data for the purpose of personal identification. Appearance-based methods, such as Gait Energy Image (GEI), have been widely adopted in gait recognition over the past 20 years due to their simplicity and high computational efficiency. However, they are known to be highly susceptible to various external factors. To address these issues, we propose a 3D gait model that employs three distinctive features: the kinematic chain feature, the skeleton orientation feature, and the joint trajectory feature. These features are designed to capture local and global, as well as spatial and temporal, correlations between joints within individual frames and across consecutive frames, enabling a more discriminative representation for person identification. In May 2026, a paper titled Individual identification using a novel 3D gait model from human joints and Joint-Features Set Abstraction was published in the journal Pattern Recognition.

Gait appearance Image



Point cloud data

(3)　As an application of remote sensing for rapid response to natural disasters, Synthetic Aperture Radar (SAR) is mounted on satellites and aircraft. Because it uses microwaves for observation, it is capable of high-precision observations over wide areas regardless of the time of day or weather conditions. In particular, it enables stable observations even in situations where optical observations are difficult, such as during disasters, and its importance is growing from the perspective of disaster prevention and mitigation. In recent years, the analysis of multiband SAR images has gained societal acceptance through international projects such as the NISAR mission, and its application to land cover classification and environmental monitoring is advancing. In this study, we develop a multiband SAR land cover classification model that incorporates a Complex-Valued Vision Transformer (CV-ViT), which enables feature extraction while preserving the phase information of complex numbers, and a bidirectional complex-valued cross-attention mechanism. As part of these results, we will present our research at ICIPW2026 in September 2026.