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**Model Klasifikasi Tumor Otak pada Citra MRI Berbasis Varian Local Binary Pattern dan Support Vector
Machine dengan Analisis Interpretabilitas LIME**
Andyan Yogawardhana, Drs. Medi, M.Kom.
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# INTISARI

## MODEL KLASIFIKASI TUMOR OTAK PADA CITRA MRI BERBASIS VARIAN LOCAL BINARY PATTERN DAN SUPPORT VECTOR MACHINE DENGAN ANALISIS INTERPRETABILITAS LIME

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Tumor otak merupakan penyakit serius yang fatal apabila tidak terdeteksi sejak dini. Magnetic Resonance Imaging (MRI) banyak digunakan sebagai media diagnosis, tetapi interpretasi manual masih bergantung pada keahlian radiolog dan berisiko menimbulkan keterlambatan maupun ketidakakuratan analisis. Di sisi lain, metode berbasis *deep learning* yang telah banyak dikembangkan mampu melakukan analisis dengan cukup baik, tetapi umumnya membutuhkan data dalam jumlah besar, sumber daya komputasi dengan performa tinggi, serta arsitektur yang kompleks dan sulit diinterpretasikan.

Penelitian ini mengembangkan model klasifikasi tumor otak berbasis citra MRI menggunakan pendekatan *machine learning* dengan kombinasi metode ekstraksi fitur tekstur Local Binary Pattern (LBP) beserta variannya dan arsitektur klasifikasi utama Support Vector Machine (SVM). Dataset Brain Tumor Classification (MRI) dari Kaggle dengan kelas glioma, meningioma, pituitary, dan otak sehat digunakan untuk pembangunan, pelatihan, dan optimasi *hyperparameter* model. Evaluasi model dilakukan menggunakan *confusion matrix* dengan metrik *accuracy*, *precision*, *recall*, dan F1-*score* serta dibandingkan dengan model *machine learning* dan *deep learning* lainnya. Sumber daya komputasi diamati dengan memperhatikan konsumsi *core* CPU dan memori RAM sistem. Model SVM dengan performa terbaik melewati proses analisis interpretabilitas Explainable Artificial Intelligence (XAI) dengan teknik LIME untuk memperoleh interpretasi visual area citra yang berpengaruh terhadap hasil prediksi.

Hasil eksperimen menunjukkan performa model berbasis *machine learning* terbaik dibangun dari kombinasi SVM dengan *kernel* RBF dengan LBP klasik *uniform* yang memperoleh akurasi makro sebesar 88,67% dan F1-*score* sebesar 0,886. Model tersebut mampu menghasilkan performa yang kompetitif dibanding arsitektur CNN sederhana berbasis *deep learning* dengan kebutuhan RAM yang lebih tinggi. Model SVM terbaik untuk acuan analisis LIME mampu memprediksi kelas sampel data dengan baik, tetapi interpretasi LIME belum menghasilkan visualisasi penjelasan kontribusi *superpixel* terhadap prediksi dengan cukup optimal. Secara umum, model klasifikasi tumor otak yang dibangun dapat menjadi alternatif solusi yang efisien dan akurat bagi fasilitas kesehatan di wilayah rural Indonesia dengan keterbatasan data maupun infrastruktur komputasi.

**Kata Kunci:** Klasifikasi Citra; Tumor Otak; Magnetic Resonance Imaging; Local Binary Pattern; Support Vector Machine; Explainable AI; LIME

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# *ABSTRACT*

## *BRAIN TUMOR CLASSIFICATION MODEL FOR MRI IMAGES USING LOCAL BINARY PATTERN VARIANTS AND SUPPORT VECTOR MACHINE WITH LIME-BASED INTERPRETABILITY ANALYSIS*

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*Brain tumors are serious and potentially fatal diseases if not detected at an early stage. Magnetic Resonance Imaging (MRI) is widely used as a diagnostic modality. However, manual interpretation still relies heavily on the expertise of radiologists and may lead to delays and inaccuracies in analysis. On the other hand, deep learning–based approaches that have been developed for medical image analysis generally require large-scale datasets, high-performance computational resources, and complex architectures that are often difficult to interpret.*

*This study proposes a brain tumor classification model based on MRI images using a machine learning approach by combining Local Binary Pattern (LBP) texture feature extraction and its variants with Support Vector Machine (SVM) as the primary classification algorithm. The Brain Tumor Classification (MRI) dataset from Kaggle, consisting of glioma, meningioma, pituitary, and healthy brain classes, was used for model development, training, and hyperparameter tuning process. Model evaluation was conducted using a confusion matrix with accuracy, precision, recall, and F1-score metrics, and the proposed model was compared with other machine learning and deep learning models. Computational resource usage was also monitored by observing CPU cores and system memory (RAM) consumptions. The best-performing SVM model was further analyzed using an Explainable Artificial Intelligence (XAI) approach through the LIME technique to provide visual interpretations of image regions that influence prediction results.*

*Experimental results show that the best-performing machine learning model was achieved using the SVM with an RBF kernel combined with classical uniform LBP, obtaining a macro accuracy of 88.67% and an F1-score of 0.886. The proposed model is capable of producing competitive performance compared to simple deep learning-based CNN architecture with higher RAM consumption. The best SVM model used as the basis for LIME analysis was able to accurately predict data sample classes. However, the LIME interpretation did not produce optimal visualizations of superpixel contributions to the predictions. Overall, the proposed brain tumor classification model offers an efficient and accurate alternative solution for healthcare facilities in rural areas of Indonesia with limited data availability and computational infrastructure.*

***Keywords:*** *Image Classification; Brain Tumor; Magnetic Resonance Imaging; Local Binary Pattern; Support Vector Machine; Explainable AI; LIME*