# DETEKSI *DIABETIC RETINOPATHY* MENGGUNAKAN METODE *HYBRID INCEPTIONRESNETV2*-KELM

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# ABSTRAK


**DETEKSI *DIABETIC RETINOPATHY* MENGGUNAKAN METODE *HYBRID INCEPTIONRESNETV2*-KELM**

*Diabetic Retinopathy* (DR) merupakan komplikasi penyakit *Diabetes Mellitus* (DM) yang terjadi pada mata. DM tipe 1 dan DM tipe 2 keduanya mengalami DR. Berdasarkan tingkat keparahannya DR dibagi menjadi stadium *mild DR*, *moderate DR*, *severe DR*, dan *proliferative DR*. Deteksi secara manual sulit dilakukan karena terdapat perbedaan yang cukup kecil antara normal dan DR, sehingga sistem *Computer-Aided Diagnosis* (CAD) menjadi solusinya. Tujuan penelitian ini adalah mendeteksi tingkat keparahan DR dengan cepat dan akurat, sehingga penderita DR tidak sampai lebih parah yang dapat menyebabkan kebutaan. Citra fundus digunakan untuk mengambil gambar fundus retina untuk mendeteksi DR. Kumpulan data citra fundus pada penelitian ini menggunakan data yang bersumber dari Mesindor. Pada data tersebut terdiri dari empat kelas yaitu normal, *mild DR*, *moderate DR*, dan *severe DR*. Metode *hybrid* dari *Convolutional Neural Network* (CNN) arsitektur *InceptionResnetV2* dengan metode KELM. *InceptionResNetV2* digunakan sebagai ekstraksi fitur dan *Kernel Extreme Learning Machine* (KELM) sebagai klasifikasinya mampu mendeteksi dengan sangat baik dan waktu yang cukup efektif. Penelitian ini menggunakan uji coba parameter KELM diantaranya menggunakan beberapa kernel seperti RBF, linear, polynomial, dan wavelet. Selain itu, juga melakukan percobaan koefisien regulasi (C) menggunakan 0.1, 1, 10, 100, dan 1000. Hasil menunjukkan nilai sensitivitas tertinggi terletak pada percobaan kernel polynomial dan $C = 10$. Hasil evaluasi menghasilkan sensitivitas sebesar 99.88%, akurasi 99.88%, spesifisitas 99.96%, presisi 99.88%, dan f1-score sebesar 99.88%.



**Kata kunci**: *Diabetes Mellitus*, *Diabetic Retinopathy*, *Convolutional Neural Network* (CNN), *InceptionResNetV2*, *Kernel Extrem Learning Machine*(KELM)

# ABSTRACT


## DIABETIC RETINOPATHY DETECTION USING THE HYBRID INCEPTIONRESNETV2-KELM METHOD

Diabetic Retinopathy (DR) is a complication of Diabetes Mellitus (DM) that occurs in the eyes. Type 1 DM and type 2 DM both experience DR. Based on the severity, DR is divided into stages of Mild DR, Moderate DR, Severe DR and Proliferative DR. Manual detection is difficult because there are quite small differences between normal and DR, so a Computer-Aided Diagnosis (CAD) system is the solution. The aim of this research is to detect the severity of DR quickly and accurately, so that DR sufferers do not get more severe, which can cause blindness. Fundus images are used to take fundus images of the retina to detect DR. The fundus image data collection in this study uses data sourced from Mesindor. This data consists of four classes, namely normal, mild DR, moderate DR, and severe DR. A hybrid method of the InceptionResnetV2 Convolutional Neural Network (CNN) architecture with the KELM method. InceptionResNetV2 is used for feature extraction and the Kernel Extreme Learning Machine (KELM) as a classifier is able to detect very well and quite effectively in time. This research uses KELM parameter tests including using several kernels such as RBF, linear, polynomial, and wavelet. Apart from that, we also conducted regulation coefficient (C) experiments using 0.1, 1, 10, 100, and 1000. The results that showed the highest sensitivity values were in the polynomial kernel experiment and $C = 10$. The evaluation results produced sensitivity of 99.88%, accuracy of 99.88%, specificity of 99.96%, precision of 99.88%, and f1-score of 99.88%.



**Keywords**: Diabetes Mellitus, Diabetic Retinopathy, Convolutional Neural Network (CNN), InceptionResNetV2, Kernel Extreme Learning Machine (KELM)

# DAFTAR ISI

# DAFTAR TABEL

# DAFTAR GAMBAR

# DAFTAR SINGKATAN

| | |
|---|---|
| Acc | : Akurasi |
| AdaGrad | : Adaptive Gradient |
| AHE | : Adaptive Histogram Equalization |
| ANN | : Artificial Neural Networks |
| BBHE | : Brightness Preserving by Histogram Equalization |
| BPDHE | : Brightness Preserving Dynamic Fuzzy Histogram Equalization |
| BV | : Blood Vessels |
| CAD | : Computer-Aided Diagnosis |
| CLAHE | : Contrast Limited Adaptive Histogram Equalization |
| CM | : Confusion Matrix |
| CNN | : Convolutional Neural Network |
| Conv | : Convolution layer |
| CV | : Cross Validation |
| DELM | : Deep Extreme Learning Machine |
| DM | : Diabetes Mellitus |
| DR | : Diabetic Retinopathy |
| EKG | : Elektrokardiogram |
| ELM | : Extreme Learning Machine |
| EX | : Exudates |
| FC | : Fully-Connected |
| FN | : False Negative |
| FP | : False Positif |

GAP : Global Average Pooling

GLAC : Gradient Local Auto-Correlations

GLCM : Gray-Level Co-occurrence Matrix

HE : Histogram Equalization

HEBPDS : dynamic stretching technique

HM : Haemorrhage

HOG : Histogram of Oriented Gradients

HRV : Heart Rate Variability

IRV2 : InceptionResNetV2

KELM : Kernel Extreme Learning Machine

KNN : K-Nearest Neighbors

LBP : Local Binary Pattern

LSTM : Long Short-Term Memory

MA : MikroAneurisma

MLELM : Multi-Layer Extreme Learning Machine

MLP : Multi-Layer Perceptron

MLSVM : Multi-Label Support Vector Machine

NAG : Nesterov Accelerated Gradient

NPDR : Non-Proliferative Diabetic Retinopathy

PCA : Principal Component Analysis

PDR : Proliferative Diabetic Retinopathy

RBF : Radial Basis Function

RGB : Red Green Blue

Sen : Sensitivitas

SGD : Stochastic Gradient Descent

SLFN : Single-layer feedforward networks

Spec : Spesifisitas

SVD : Singular Value Decomposition

SVM : Support Vector Machine

T1DM : Diabetes Melitus tipe 1

T2DM : Diabetes Melitus tipe 2

TN : True Negative

TP : True Positive

WHO : World Health Organization

# DAFTAR SIMBOL

| | |
|---|---|
| $C$ | : Koefisien regulasi |
| $\boldsymbol{H'}$ | : Matriks Hidden nodes yang ditransposekan |
| $\boldsymbol{H^{-1}}$ | : Matriks Hidden nodes yang diinverskan |
| $\boldsymbol{\Omega_{ELM}}$ | : Matriks omega kernel |
| $\boldsymbol{\beta}$ | : Matriks bobot output |
| $\mathbb{R}^{N \times N}$ | :Bilangan real berdimensi $N \times N$ |
| $\boldsymbol{H}^{\dagger}$ | : Matriks Moore-Penrose Generalized Inverse dari matriks H |
| $R_{ij}$ | : Nilai confusion matriks pada kelas i terprediksi ke dalam kelas j |
| $k(.)$ | : Fungsi kernel |
| $\boldsymbol{Y}_{out}$ | : Vektor output prediksi |
| $Y$ | : Target kelas |

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