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# To Predict Tropical Cyclone Intensity by BPPF vs. GF with Machine Learning

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**ABSTRACT:** This study presents an evaluation of multiple classifiers to predict cyclone intensity, focusing on their performance metrics, including accuracy, precision, recall, ROC, and PRC scores. The classifiers tested are combinations of BPPF (Binary Patterns Pyramid Filter) and GF (Gabor Filter) models with different machine learning algorithms, namely Multilayer Perceptron (MLP), Random Forest (RF), and Instance-Based K-nearest neighbor (IBK). Among these, the BPPF+IBK classifier outperforms others, achieving the highest accuracy (90.50%), precision (0.91), recall (0.90), and nearly perfect ROC and PRC values of 0.98 each, indicating superior capability in distinguishing between cyclone intensity classes with minimal errors. Comparatively, BPPF+RF and BPPF+MLP also demonstrate strong and balanced performances, making them reliable alternatives when precision and recall are prioritized. The GF-based models generally show slightly lower predictive performance, with GF+IBK being the least effective, displaying lower accuracy and weaker discriminative power. These results underline the effectiveness of using BPPF-based classifiers, particularly BPPF+IBK, for accurate and reliable cyclone intensity prediction, highlighting their potential in enhancing early warning systems and disaster preparedness measures.

**KEYWORDS:** Binary Patterns Pyramid Filter, Tropical Cyclone, Gabor Filter, IBK, Intensity

## I. INTRODUCTION

Cyclone intensity prediction is a critical aspect of meteorological science aimed at forecasting the strength, size, and potential impacts of cyclones. Cyclones, known as hurricanes or typhoons in different regions, are among the most destructive natural disasters, with their intensity playing a key role in determining the level of damage they may cause to lives, infrastructure, and the environment. Accurate prediction is essential for effective disaster preparedness, risk mitigation, and emergency response planning. Predicting the intensity of cyclones is a complex task that relies on the analysis of a range of atmospheric, oceanographic, and environmental variables. These include sea surface temperatures, wind shear, atmospheric pressure patterns, moisture content, and ocean heat content, among others. Advanced modeling techniques, including numerical weather prediction models, statistical approaches, and machine learning algorithms, are employed to analyze and forecast cyclone intensities. The accuracy of these predictions has improved over the years due to advancements in satellite technology, high-performance computing, and increased understanding of the underlying dynamics of cyclones.

Despite these advancements, challenges remain in achieving consistently precise intensity predictions due to the inherently chaotic nature of weather systems and the influence of rapidly changing environmental conditions. Continued research and innovation in this field aim to enhance prediction models, integrate diverse data sources, and better understand the physical processes driving cyclones, ultimately reducing the devastating impact of these natural phenomena on society.

This work organizes section 2 has literature survey, section 3 has materials and methods and section 4 has results and discussions and section 5 has conclusions.

### II. LITERATURE SURVEY

This work focuses the related works of this research. This study [1] focuses on a hybrid-CNN model combined satellite spatial characteristics and numerical prediction outputs to improve TC intensity forecasts at lead times of 24, 48, and 72 hours, with significant improvements over the Korea Meteorological Administrator (KMA) forecasts. The Authors [2] proposes an automated neural network-based method integrated Sentinel-2A satellite images and crowdsourced geospatial data for precise UGS mapping, achieving a 94.6% classification accuracy using multi-scale feature extraction, multi-modal information fusion, and boundary enhancement modules. The authors [3] utilized an ensemble of DeepLabV3+ sub-models, each accepting three input channels, to segment snow using Sentinel-2 data, outperforming traditional spectral indices with mIoU values from 0.8075 to 0.9538. The authors [4] estimated by A 1D-CNN major and minor algal pigments using hyperspectral data, providing spatial maps for algal biomass and species distribution, with  $R^2$  values of 0.71 to 0.87 for key pigments. The authors [5] proposed a lightweight CNN for efficient forest mapping using Landsat imagery and analyzed forest composition changes over a decade, achieving higher accuracy and efficiency compared to deeper networks like VGG16 and Resnet. This system has [6] the SimVP model generated radar-based precipitation forecasts up to 120 minutes ahead, demonstrating better performance than existing models for different precipitation scenarios, such as heavy rainfall and typhoons. The authors [7] developed a lightweight CNN for fast geometric correction and resolution enhancement of satellite images, achieving substantial quality improvements in terms of PSNR and processing speed. The authors proposed [8] a two-step ML approach used DINCAE and LGBM models to fill spatiotemporal gaps in SST data, yielding high reconstruction accuracy ( $R^2 = 0.98$ ) with reduced overfitting. This system analysis [9] of climatological and statistical of typhoon paths hitting Taiwan over 40 years, linking rising typhoon intensity to increasing sea surface temperatures and El Niño events, reflecting global warming's impact. Each study highlights innovative AI [10-14] and DL approaches tailored to complex environmental challenges, contributing valuable tools and insights for forecasting, mapping, and monitoring vital aspects of climate and environmental science

### III. MATERIALS AND METHODS

The dataset borrowed from Kaggle data repository named as Imagery (2012-2021) (INSAT3D). [36]. It has 136 infrared images and 140 raw images of tropical cyclone images over the Indian Ocean from 2012 to 2021. This work considers infrared images only. The dataset used in 80:20 cross fold vadiation by using Weka3.9.6 tool for getting optimal solution.

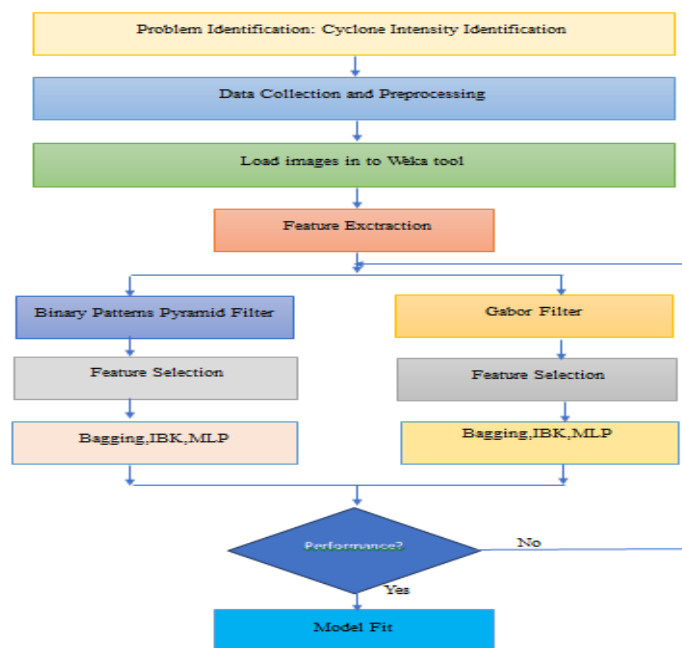


Figure 1: proposed system



**Table 1: Classification Metrics**

S.No	Classifier	Accuracy	Precision	Recall	ROC	PRC
1	BPPF+MLP	86.92%	0.9	0.86	0.94	0.94
2	BPPF+RF	87.61%	0.89	0.87	0.95	0.94
3	BPPF+IBK	90.50%	0.91	0.9	0.98	0.98
4	GF+MLP	87.50%	0.87	0.87	0.95	0.94
5	GF+RF	85.27%	0.91	0.85	0.94	0.93
6	GF+IBK	84.50%	0.85	0.84	0.85	0.79

BPPF(Binary Patters Pyramid Filter)+MLP (Multilayer Perceptron) shows a solid performance with an accuracy of 86.92%, indicating that it correctly predicts a high proportion of instances. With a precision score of 0.90, it demonstrates a strong ability to minimize false positives, ensuring that most of its positive predictions are accurate. However, its recall of 0.86 suggests that it misses a small portion of actual positive instances. The high ROC and PRC scores (both 0.94) indicate strong overall discrimination between positive and negative classes and a good balance between precision and recall. This makes BPPF+MLP a reliable choice when precision is a key priority.

BPPF(Binary Patters Pyramid Filter)+RF (Random Forest) offers slightly higher accuracy at 87.61% compared to BPPF+MLP, along with a balanced precision of 0.89 and recall of 0.87. The high ROC score of 0.95 and PRC of 0.94 suggest that this classifier is excellent at distinguishing between classes. This balance between precision and recall, along with strong accuracy, makes BPPF+RF an effective and consistent performer with minimal trade-offs between false positives and false negatives.

BPPF(Binary Patters Pyramid Filter)+IBK (Instance-Based K-nearest neighbor) stands out as the best-performing classifier with an impressive accuracy of 90.50%, precision of 0.91, and recall of 0.90. Its extremely high ROC and PRC scores of 0.98 each reflect a nearly perfect ability to differentiate between positive and negative instances. This classifier provides the best overall predictive capabilities, demonstrating robustness and reliability in identifying relevant instances while minimizing both false positives and false negatives. As such, BPPF+IBK is highly recommended for scenarios demanding top-tier accuracy and balanced prediction outcomes.

GF(Gabor Filter)+MLP (Multilayer Perceptron) also shows strong performance, achieving an accuracy of 87.50%. It maintains balanced precision and recall scores of 0.87 each, indicating that it performs well in correctly predicting both positive and negative instances. The high ROC value of 0.95 and PRC of 0.94 further reinforce its effectiveness in distinguishing between classes. Although it trails slightly behind BPPF+IBK in terms of accuracy, GF+MLP remains a reliable classifier with strong overall performance.

GF(Gabor Filter)+RF (Random Forest) has an accuracy of 85.27% and a high precision of 0.91, indicating that it is effective at minimizing false positives. However, its recall is slightly lower at 0.85, meaning it may not capture all relevant positive instances. With an ROC of 0.94 and PRC of 0.93, this classifier demonstrates solid discriminative ability but is slightly less consistent compared to its BPPF counterpart. The high precision, however, makes it suitable for cases where false positives are particularly costly.

GF(Gabor Filter)+IBK (Instance-Based K-nearest neighbor) exhibits the lowest overall performance, with an accuracy of 84.50% and precision and recall scores of 0.85 and 0.84, respectively. The relatively lower ROC of 0.85 and PRC of 0.79 suggest that it is less effective at distinguishing between positive and negative instances compared to the other classifiers. Its lower accuracy and discriminative power make it the least optimal choice among the classifiers analyzed, indicating room for improvement.

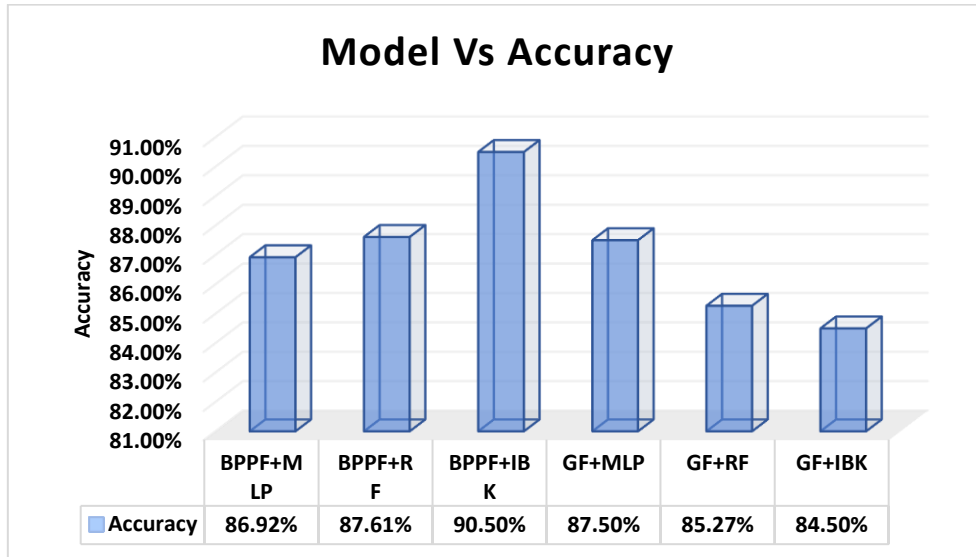


Figure 2: Model vs. Accuracy

The chart 2 illustrates the accuracy of different model configurations, comparing various combinations of models and techniques. It shows that the "BPPF + IBK" model configuration achieves the highest accuracy at 90.50%, while "GF + IBK" has the lowest at 84.50%. Other configurations, such as "BPPF + MLP" and "BPPF + RF," also show strong performance, with accuracy rates of 86.92% and 87.61%, respectively.

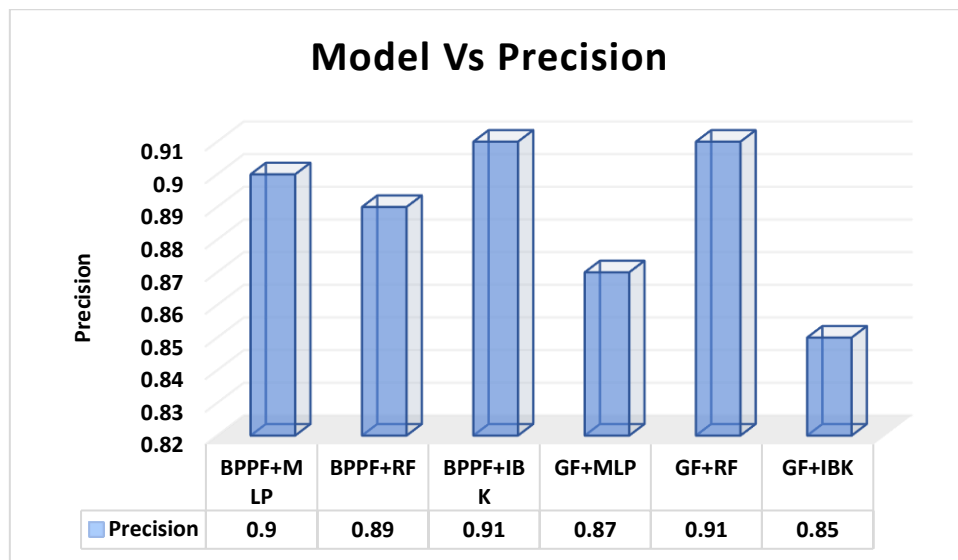


Figure 3: Model vs. Precision

The chart 3 displays the precision of different model configurations, highlighting their comparative performance in terms of precision. "BPPF + IBK" and "GF + RF" configurations share the highest precision value at 0.91. On the other hand, "GF + IBK" has the lowest precision among the displayed models at 0.85. Other notable configurations include "BPPF + MLP" with a precision of 0.9 and "BPPF + RF" at 0.89.

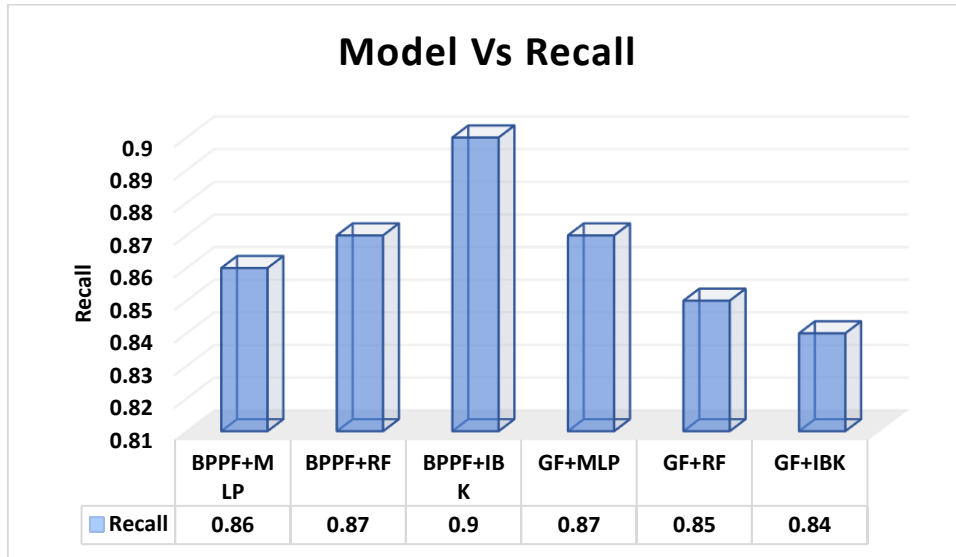


Figure 4: Model vs. Recall

The chart 3 shows the recall performance of various model configurations. The "BPPF + IBK" configuration demonstrates the highest recall value at 0.9, indicating a strong ability to correctly identify relevant cases. "BPPF + RF" and "GF + MLP" both have a recall of 0.87, while "GF + RF" has a slightly lower recall at 0.85. The configuration with the lowest recall among the displayed models is "GF + IBK" at 0.84.

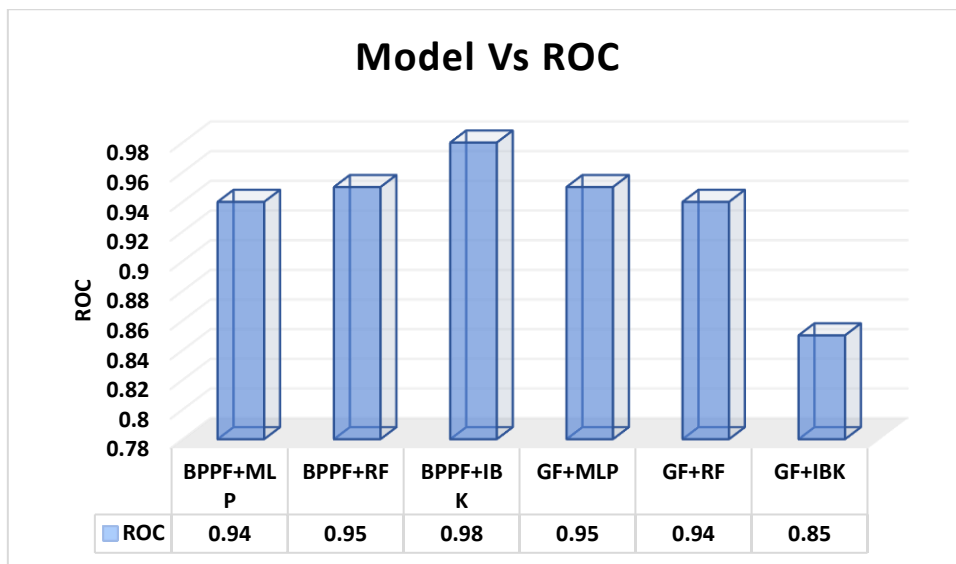


Figure 5: Model vs. ROC

This chart 4 presents the ROC (Receiver Operating Characteristic) values for different model configurations. "BPPF + IBK" achieves the highest ROC score at 0.98, indicating a superior balance of sensitivity and specificity. "BPPF + RF" and "GF + MLP" follow closely with ROC values of 0.95. Meanwhile, "BPPF + MLP" and "GF + RF" both have slightly lower ROC values at 0.94. The lowest value among the displayed configurations is "GF + IBK" at 0.85.

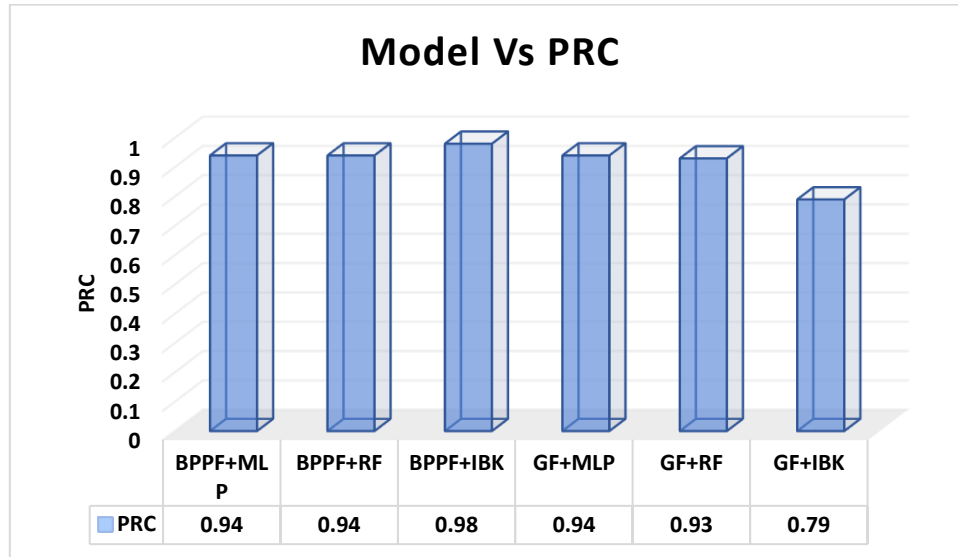


Figure 6: Model vs. PRC

This chart 5 illustrates the PRC (Precision-Recall Curve) values for different model configurations. The “BPPF + IBK” model configuration stands out with the highest PRC value of 0.98, indicating excellent precision-recall performance. “BPPF + MLP,” “BPPF + RF,” and “GF + MLP” all share a PRC value of 0.94, demonstrating strong performance. “GF + RF” has a slightly lower PRC at 0.93, while the “GF + IBK” configuration has the lowest PRC value at 0.79 among the displayed models.

#### IV. CONCLUSION

This work concludes that the BPPF+IBK emerges as the best overall performer, providing high accuracy and a balanced precision-recall trade-off, while GF-based classifiers generally show slightly lower performance than their BPPF counterparts. GF+IBK appears to be the least effective, highlighting a need for potential refinement or reconsideration in its application.

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