**MAR ATHANASIUS COLLEGE OF ENGINEERING**

**(Affiliated to APJ Abdul Kalam Technological University, TVM)**

**KOTHAMANGALAM**



**Department of Computer Applications**

Mini Project Report

**STAR-GALAXY CLASSIFICATION**

**USING DEEP LEARNING**

Done by

**Ajay Das M**

**Reg No : MAC22MCA-2014**

Under the guidance of

**Prof. Nisha Markose**

**2022-2024**

**MAR ATHANASIUS COLLEGE OF ENGINEERING**

**(Affiliated to APJ Abdul Kalam Technological University, TVM)**

**KOTHAMANGALAM**

**CERTIFICATE**



**Star-Galaxy Classification Using Deep Learning**

Certified that this is the bonafide record of project work done by

**Ajay Das M**

### Reg No: MAC22MCA-2014

during the third semester, in partial fulfilment of requirements for award of the degree

**Master of Computer Applications**

of

**APJ Abdul Kalam Technological University Thiruvananthapuram**

**Head of the Department**

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**Faculty Guide**

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**ACKNOWLEDGEMENT**

With heartfelt gratitude, I extend my deepest thanks to the Almighty for His unwavering grace and blessings that have made this journey possible. May His guidance continue to illuminate my path in the years ahead.

I am immensely thankful to Prof. Biju Skaria, Head of the Department of Computer Applications and my mini project guide, and Prof. Nisha Markose, our dedicated project coordinator, for their invaluable guidance and timely advice, which played a pivotal role in shaping this project. Their guidance, constant supervision, and provision of essential information were instrumental in the successful completion of the mini project.

I extend my profound thanks to all the professors in the department and the entire staff at MACE for their unwavering support and inspiration throughout my academic journey. My sincere appreciation goes to my beloved parents, whose guidance has been a beacon in every step of my path.

I am also grateful to my friends and individuals who generously shared their expertise and assistance, contributing significantly to the fulfillment of this endeavor.

**ABSTRACT**

The challenge of accurately classifying astronomical objects as stars or galaxies has been a fundamental task in astrophysics for centuries. Traditional methods relied heavily on visual inspection and morphological analysis, which were labour-intensive and limited by human subjectivity and the capacity to process large data volumes. With the advent of modern sky surveys like the Sloan Digital Sky Survey (SDSS), the volume of astronomical data has grown exponentially, rendering manual classification impractical.

The literature survey across the reviewed papers highlights three algorithms Convolution Neural Network (CNN), deep convolutional neural networks (ConvNets), ContextNet where taken into consideration.

The performance of deep learning architecture Convolution Neural Network (CNN) is used to classify stars and galaxies. Steps include rejecting data with errors, correcting for extinction, aligning images, and centring objects using nMontage and SExtractor.

The Dataset is taken from the Kaggle repository, the dataset contains 3986 data which 942 galaxy 3044 Star data.

Among the three Architecture, the Convolution Neural Network (CNN) is found to be best in terms of model building and computation. Thus, Star-Galaxy Classification Using Deep learning offers significant benefits for star-galaxy classification, including reduced human error, increased scalability, and efficient handling of vast data quantities.

**References:**

* Ganesh Ranganath Chandrasekar Iyer Krishna Chaithanya Vastare (2017). Deep Learning for Star-Galaxy Classification
* Kim EJ, Brunner RJ. Star-galaxy classification using deep convolutional neural networks. Monthly Notices of the Royal Astronomical Society. 2016 Oct 17:stw2672.
* Kennamer N, Kirkby D, Ihler A, Sanchez-Lopez FJ. ContextNet: Deep learning for star galaxy classification. In International conference on machine learning 2018 Jul 3 (pp. 2582-2590). PMLR.

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**1. Introduction**

The challenge of accurately classifying astronomical objects as stars or galaxies has been a fundamental task in astrophysics for centuries. Traditional methods relied heavily on visual inspection and morphological analysis, which were labour-intensive and limited by human subjectivity and the capacity to process large data volumes. With the advent of modern sky surveys like the Sloan Digital Sky Survey (SDSS), the volume of astronomical data has grown exponentially, rendering manual classification impractical.

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**2.** **SUPPORTING LITERATURE**

**2.1 Literature Review**

Paper 1: *Ganesh Ranganath Chandrasekar Iyer Krishna Chaithanya Vastare (2017). Deep Learning for Star-Galaxy Classification*

This project explores a CNN-based classifier to address these limitations. The paper "Deep Learning for Star-Galaxy Classification" (2017) demonstrates that Convolutional Neural Networks (CNNs) can effectively distinguish between stars and galaxies in astronomical images, achieving higher accuracy than traditional methods.

Table 2.1.1. Summ

|  |  |
| --- | --- |
| **Title of the paper** | Ganesh Ranganath Chandrasekar Iyer Krishna Chaithanya Vastare (2017). Deep Learning for Star-Galaxy Classification |
| **Area of work** | Using deep learning, specifically Convolutional Neural Networks (CNNs), for classifying stars or galaxies. |
| **Dataset** | Dataset was taken from the Sloan Digital Sky Survey (SDSS). The dataset contains 30 million images. |
| **Methodology / Strategy** | CNN-based binary star-galaxy classifier involves collecting labelled image data from sources like the SDSS, pre-processing the data by normalizing and resizing images, and splitting it into training, validation, and test sets. A CNN is designed with convolutional and pooling layers for feature extraction, followed by fully connected layers for classification, with a sigmoid output layer for binary classification. The model is trained using binary cross-entropy loss and the Adam optimizer, then evaluated using accuracy, precision, recall, and F1-score metrics. Finally, the trained model is deployed to classify new astronomical data. |
| **Architecture** | Convolutional Neural Networks(CNN) |
| **Result/Accuracy** | CNN(Convolutional Neural Networks) – 99.19 |

Paper 2 : *Kim EJ, Brunner RJ. Star-galaxy classification using deep convolutional neural networks. Monthly Notices of the Royal Astronomical Society. 2016 Oct 17:stw2672.*

Kim and Brunner (2016) developed a deep CNN approach for classifying stars and galaxies in astronomical images. Their method improves accuracy by effectively learning from the features in the images, outperforming traditional classification techniques.

|  |  |
| --- | --- |
| **Title of the paper** | Kim EJ, Brunner RJ. Star-galaxy classification using deep convolutional neural networks. Monthly Notices of the Royal Astronomical Society. 2016 Oct 17:stw2672. |
| **Area of work** | Star-galaxy classification using deep convolutional neural networks. |
| **Dataset** | photometric and spectroscopic data sets with different characteristics and compositions.  data sets and the image pre-processing steps for retrieving cutout images |
| **Methodology / Strategy** | The research uses deep convolutional neural networks (ConvNets) to classify astronomical objects from SDSS and CFHTLenS survey data. The ConvNet, with several convolutional and fully connected layers, employs data augmentation and dropout to reduce over fitting. The study compares ConvNet performance to the Trees for Probabilistic Classifications (TPC) algorithm, focusing on accuracy and probabilistic calibration. |
| **Architecture** | Convolutional Neural Networks (ConvNets) |
| **Result/Accuracy** | ConvNet - 99.48 |

Paper 3 : *Kennamer N, Kirkby D, Ihler A, Sanchez-Lopez FJ. ContextNet: Deep learning for star galaxy classification. In International conference on machine learning 2018 Jul 3 (pp. 2582-2590). PMLR.*

The paper titled "ContextNet: Deep Learning for Star Galaxy Classification" presents a framework for classifying stars and galaxies in astronomical images, specifically for data from the Large Synoptic Survey Telescope (LSST)

|  |  |
| --- | --- |
| **Title of the paper** | Kennamer N, Kirkby D, Ihler A, Sanchez-Lopez FJ. ContextNet: Deep learning for star galaxy classification. In International conference on machine learning 2018 Jul 3 (pp. 2582-2590). PMLR. |
| **Area of work** | The work applies ContextNet Architecture to classify stars and galaxies in astronomical images from ground-based surveys like the LSST |
| **Dataset** | The dataset used in the work consists of simulated images from the Large Synoptic Survey Telescope (LSST) observations, generated using the GalSim image simulation package. |
| **Methodology / Strategy** | The methodology uses ContextNet, a three-step neural network framework. It includes a local network for individual object features, a global network for comparing features across objects to capture context, and a prediction network that combines these features for classification. This approach handles non-IID data and improves accuracy by leveraging neural network weight replication for variable object numbers in each exposure. |
| **Architecture** | **Local Network**: Convolutional Neural Networks (CNNs)  **Global Network**: Recurrent Neural Networks (RNNs)  **Prediction Network**: Fully Connected Neural Networks (FCNs) |
| **Result/Accuracy** | ContextNet - 95% |

**2.1.4 SUMMARY TABLE**