INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH IN ENGINEERING AND MANAGEMENT (IJSREM)
VOLUME: 08 ISSUE: 05 | MAY - 2024 SJIF RATING: 8.448 ISSN: 2582-3930

Heritage Identification of monuments using Deep Learning Techniques

ROHAN SALUJA
APEX INSTITUTE OF TECHNOLOGY
CHANDIGARH UNIVERSITY
MOHALI,PUNJAB
20BCS6730@CUCHD.IN

SAMRAT CHATTERJEE
APEX INSTITUTE OF TECHNOLOGY
CHANDIGARH UNIVERSITY
MOHALI,PUNJAB
20BCS6767@CUCHD.IN

BHAL CHANDRA VED
APEX INSTITUTE OF TECHNOLOGY
CHANDIGARH UNIVERSITY
MOHALI,PUNJAB
20BCS6772@CUCHD.IN

MANSI RAGHAV
APEX INSTITUTE OF TECHNOLOGY
CHANDIGARH UNIVERSITY
MOHALI,PUNJAB
20BCS6745@CUCHD.IN

***Abstract*— The Heritage Identification of Monuments web application employs different Machine learning technologies like Convolutional Neural Networks(CNN) and Deep Learning, to identify historical sites and monuments. The project focuses on training machine learning model to identify heritage sites and monuments with the use of CNN to extract features from images and help in identifying historical monuments. This project focuses on collection data from satellite images and user contributions, thus expanding the database and offering information on different identified monuments. This initiative aims to promote general awareness among the public and promote heritage preservation with labelled datasets and machine learning technologies.**

Machine learning techniques have evolved over the years, in this project we highlight the main techniques and algorithms by which we extract data from images and compare different mathematical models to test the accuracy. Additionally, the web-app helps to create a good reach among the masses and raise awareness.

Keywords*— Machine learning, Deep Learning, Convolution Neural Network (CNN), Pattern Recognition, Indian Monuments, Open source.

I. INTRODUCTION

In the modern times, the world has shifted to everything digital whether its our pictures or important things like identity cards we tend to forget our past, most importantly how we reached where we are today. There are many historical sights and monuments that helps us remind who we are and the technical feat that has been achieved thousands of years ago like the Pyramids in Egypt or the Clock tower in Jaipur. These monuments help us understand how the world worked back then and how we can learn to improve ourselves, but today's generation is very tech savy and to retain and catch attention it takes more than just beautiful monuments. For many years the government as well as the archeological survey of India excavated and documented many heritage sites but this never really reached the masses, the masses only goes to popular sites and the rest just gets unlooked and that should not happen. The popular tourist's places are well documented but can always be improved and a central database should be made. With the on

coming of satellites documenting different sites and monuments has become relatively easy the work that used to consume hours of works now can be done with new technologies like different image processing and deep learning algorithms. Even though fieldworks are still very important but if integrated with computer visions and other technologies this can become even more efficient, even with satellite images it possesses a lot of difficulties like subtle architectural variations, the irregularities in the image itself like different perspectives, lighting conditions, color differences, contrast and point of view.

Fig 1. Data of most visited monuments of India.

Today many a times we see a historical site and wonder what its name is and what its history is, if you're in a popular site you have many boards and guides to tell you about it but if it's a rather unexplored place you don't have anything to rely on and toidentify the structure it's a huge fuzz, moreover there are many language barriers and low availability of labelled datasets this makes making a machine learning algorithm much more complex and difficult. Automated heritage monument detection carries a lot of benefits such as boosting tourism, spreading awareness and preservation of our heritage by creating a central digital database, but a database cannot be a good one unless its an open-source where anyone can share and add information which can then be verified and added to the database.

In our Research paper we focus on solving the following problems and use a different approach to solve such problems:

- Apply different machine learning and deep learning techniques to recognize monuments from the image that will be uploaded by the user.
- Create an Open-Source database to gather information and different images of a monument like with different angles, different image colors and lighting conditions, this will allow us to create a varied and large database and can be used to train and test models much more effectively and accurately.
- With this database different studies can be done regarding the conditions of the monuments and Archeologists can use it for various studies and carbon-dating.
- This will help to spread awareness among the general public and also rope in the young generation to learn in a new interactive and fun way , while also promoting tourism and conservation of the historical legacy.

In Chapter 2, we will give a summary of related work in the that has been conducted in this field. In Chapter 3, we describe the methodology.In Chapter 4, we will give results and the analysis. Finally, in Chapter 5 we conclude this article and discuss some potential directions for future research.

II. LITERATURE REVIEW

With the rise in machine learning and deep learning techniques, it has presented us with a variety of opportunities specially in the field of image recognition. These techniques have further been used in the domain of heritage identification and preservation of monuments and its history. This literature review takes us through the flow in which a project on monument identification works and the problems that are faced along the way.

Initial approach to Heritage Identification

Image-Based Identification: Traditional methods such as SIFT (Scale-Invariant Feature Transform) and SURF (Speeded-Up Robust Features) were widely used for image matching and object recognition [1]. Though effective to an extent, they lacked the power of end-to-end learning that DL models offer.

Semantic Segmentation: Initial attempts in heritage recognition involved segmenting images to detect and identify different parts of a monument. CNN-based methods have been applied for the segmentation task in heritage conservation [2].

Different Deep Learning Techniques

Convolutional Neural Networks (CNNs): CNNs, with their spatial hierarchy model, have outperformed traditional methods in image classification tasks [3]. Several works have shown the use of CNNs in classifying and identifying monuments from image datasets.

Transfer Learning: Given the scarcity of data in some heritage tasks, transfer learning has been employed, where pre-trained models on large datasets, such as ImageNet, are fine-tuned on smaller monument datasets [4].

Generative Adversarial Networks (GANs): GANs have shown promise in generating 3D models of monuments from 2D images, helping in reconstruction and virtual tourism applications [5].

Challenges faced in Deep learning techniques

Diverse Architectural Styles: Monuments exhibit a wide range of architectural styles, often within the same monument. This diversity can pose challenges to consistent identification [6].

Data Scarcity: Many heritage sites are unique, leading to a scarcity of data, thus posing challenges for DL models that require large amounts of data [7].

Environmental Factors: Changes in lighting, weather, and seasons can greatly affect monument images, leading to inconsistencies in identification [8].

Recent Innovation in this field

Few-Shot Learning: With the challenge of data scarcity, few-shot learning techniques have been explored to train models on a very limited dataset and still achieve commendable accuracy [9].

Augmented Reality (AR): Integration of DL with AR has opened avenues for interactive heritage tourism, where real-time information about monuments can be superimposed on AR devices [10].

Monument Health Monitoring: DL, combined with IoT, is being used to monitor the health and decay of monuments, enabling timely conservation efforts [11].

Deep learning's potential in heritage monument identification is profound, yet challenges persist. Beyond just recognizing these structures, there's an imperative to preserve and elevate our cultural history. Integrating technological advancements with the nuances of heritage conservation opens doors to innovative solutions. Continued exploration in this intersection is vital, promising transformative breakthroughs that not only enhance our understanding of historical monuments but also underscore their enduring cultural importance.

III. METHODOLOGY

The research paper being discussed presents a image upload to detect heritage monuments that utilizes deep learning techniques, specifically employing a convolutional neural network (CNN) for image recognition. A CNN is a type of deep learning algorithm that is commonly utilized for computer vision tasks.

1. Data Collection

In this particular project, we have tried to create a diverse dataset with satellite images and labelled them accordingly. This dataset contains a variety of images including different angles and different lighting conditions. The dataset was collected in the following manner:

- Data Sources: The images of monuments were collected from satellite images (Google Earth), Mobile photos with different angles possible to get a comprehensive representation. Moreover, images from the web are also taken into account to get a more realistic view of every monument.

- Data Labeling: Different monuments were labelled properly according to Wikipedia and Archaeological Survey of India. Moreover, users can add to the database as it will be an open-source project. This data then gets labelled properly from the competent authorities.

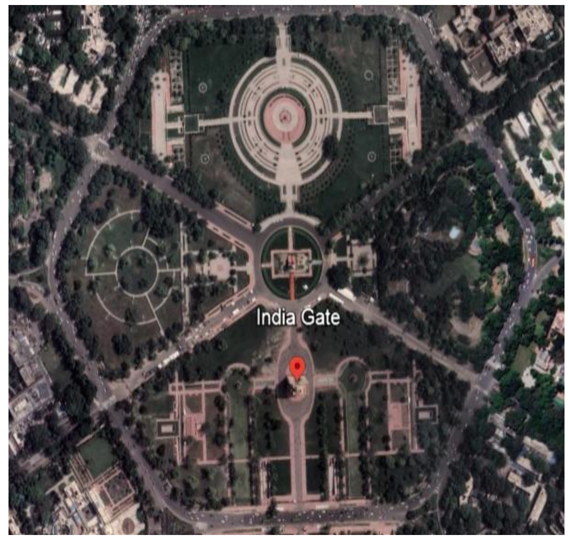

FIG 2: Satellite image collection.

2. Data Preprocessing

After the dataset is built, the images underwent a series of pre-processing steps to standardize and prepare it feature extraction and train and test split:

Image Resizing: The images that were collected were resized to a consistent resolution of 200x200 pixels to ensure uniformity and have a consistent dataset.

Image Detection: A deep-learning algorithm which uses a Convolutional Neural Network(CNN). VGG16 which is a object detection and classify algorithm is also used to identify and classify monuments within each input image. This step ensures that the input image is consistently recognized and categorized into the correct class based on the features.

Data Augmentation: To remove errors and have a good image set different data augmentation techniques like flips, random rotations, color correction, brightness correction, random rotations were applied to the dataset.

VOLUME: 08 ISSUE: 05 | MAY - 2024 SJIF RATING: 8.448 ISSN: 2582-3930

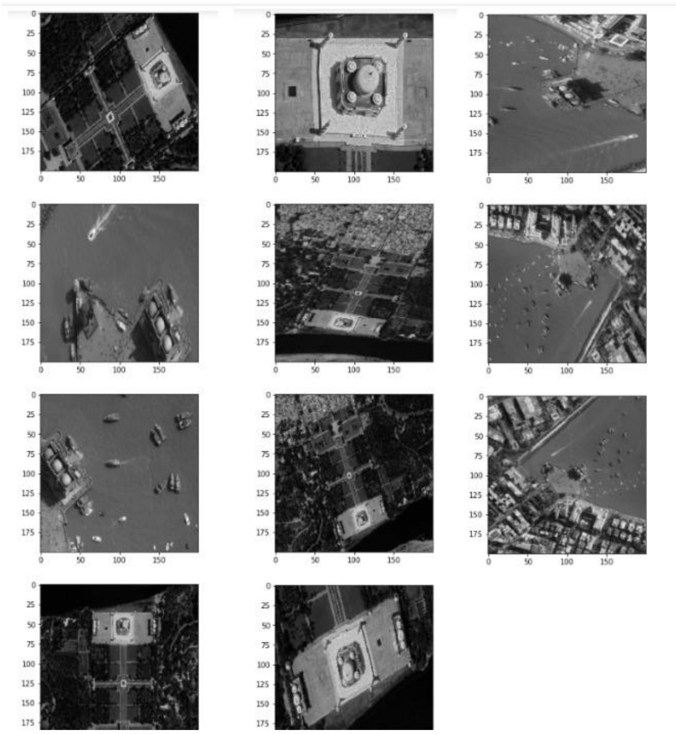

FIG 3: Greyscale images of monuments.

3. Monument Classification Model

The model that we designed uses the processed satellite images to detect the monument in the image that is uploaded by the user. The monument classification model consists of the following components:

Convolutional Neural Network (CNN): A convolutional neural network was used as the primary feature extractor. This CNN architecture comprised multiple convolutional layers followed by max-pooling and batch normalization layers.

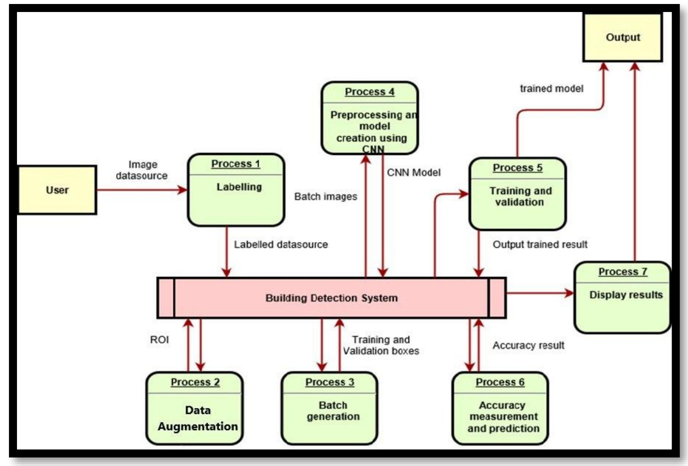

FIG 4: CNN Algorithm

Flatten and Fully Connected Layers: The extracted features were flattened and connected to fully connected layers, which gradually reduced the dimensions and mapped them to the desired categories.

Output Layer: The final output layer consisted of softmax activation to produce probability distributions over the detected classes.

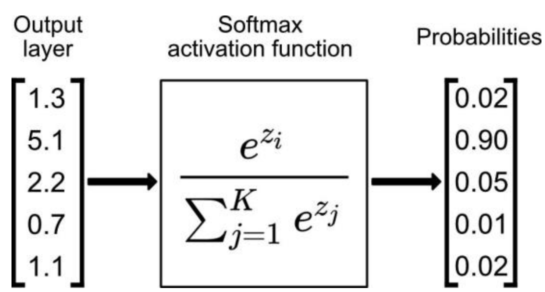

FIG 5: Softmax Function

4. Model Training and Evaluation

The dataset was divided into three sets: Training, Testing and Validation. The following steps were taken to train and test the classification models:

Training: The model was trained using mini batch gradient descent (RMSProp) with a learning rate schedule. Cross-entropy loss was used as the objective function.

```
#training data
generator_top = datagen.flow_from_directory(
    train,
    target_size = (img_width, img_height),
    batch_size = batch_size,
    class_mode = 'categorical',
    shuffle = False
)

nb_train_samples = len(generator_top.filenames)
num_classes = len(generator_top.class_indices)

#load the bottleneck features saved earlier
train_data = np.load('bottleneck_features_train.npy')

#get the class label for the training data in the original order
train_labels = generator_top.classes

#convert the training labels to categorical vectors
train_labels = to_categorical(train_labels, num_classes = num_classes)
```

FIG 6: Code for Training Data

Validation: The performance of the model was checked on the validation set to prevent overfitting. Techniques like early stopping was used to halt training if validation performance did not improve.

```
#testing data
generator_top = datagen.flow_from_directory(
    test,
    target_size = (img_width, img_height),
    batch_size = batch_size,
    class_mode = None,
    shuffle = False
)

nb_test_samples = len(generator_top.filenames)

test_data = np.load('bottleneck_features_test.npy')

test_labels = generator_top.classes
test_labels = to_categorical(test_labels, num_classes = num_classes)
```

FIG 7: Code for Testing Data

Evaluation Metrics: Model performance was evaluated using metrics such as accuracy, F1 score.

	precision	recall	f1-score	support
Fatehpur Sikri	0.96	1.00	0.98	7
India Gate	0.95	0.95	0.95	6
Qutub Minar	1.00	1.00	1.00	6
Statue of Unity	1.00	0.95	0.97	6
gatewayofindia	1.00	1.00	1.00	9
tajmahal	1.00	1.00	1.00	9
micro avg	1.00	1.00	1.00	43
macro avg	1.00	1.00	1.00	43
weighted avg	1.00	1.00	1.00	43
samples avg	1.00	1.00	1.00	43

FIG 8: Evaluation matrix

Apart from the code for the Model classifier that we have created that is running in the backend. The data that is taken from the user is taken to a web-application where the user has the choice of uploading an image. This image is then sent to the backend where all the necessary steps are done to identify the Image that has been uploaded by the user. If it gets recognized correctly then the image from the database is shown on the screen.

React was used to build the web application. When the NPM is build the website gets compiled and run on localhost. The first webpage shows the title of the website/project and gives the option to upload the file which the user wants to identify.

FIG 9: Intro Page

After this the user can select the upload file option. It will redirect to the local machine from which they can choose the file they want to upload.

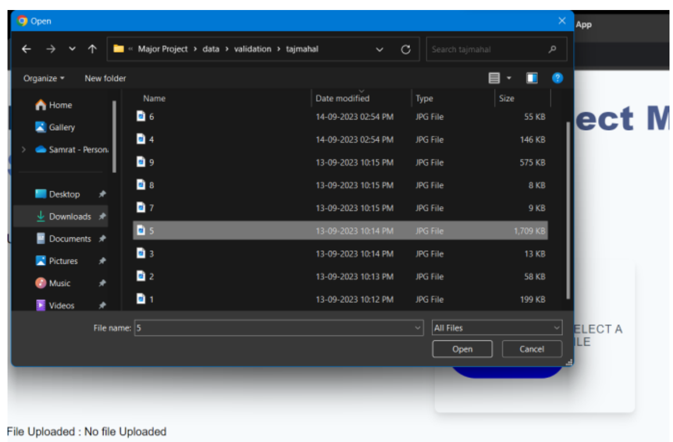

FIG 10: Upload file Option

After that the predict option is selected and a push message comes that shows the file has been successfully uploaded. Then the data is forwarded to the backend(server.py) which then runs the data and produce the output. The data that is given is run through the "monument_classifier.h5" which then runs the whole Monument detection model and the output is then again send to the website, then the output is shown along with the details of the monument that is already saved in the database.

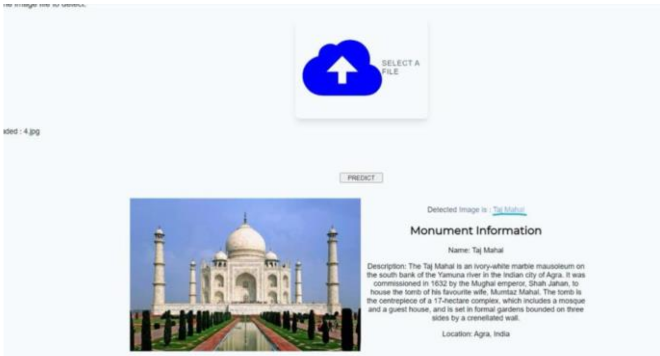

FIG 11: Output Image

IV.RESULT AND ANALYSIS

The web application is made as a layer of abstraction between the developer's code and the user. The user need not to know how that image is getting recognized. The React app connects the front end with the backend file which allows to accept the images and then run it through the classifier and produce the output from the database that is already present.

If the user put this image as the input image then:

FIG 12: Input Image (Top view of the Taj Mahal)

After prediction the output will be this:

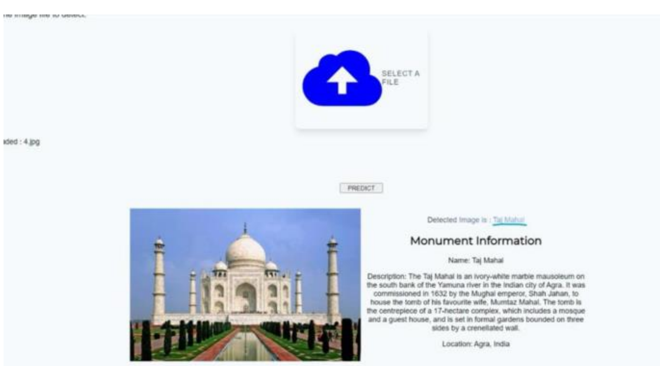

FIG 13: Result

Analysis:

In our study, we achieved promising results, including an F1 score of 80%, an overall classification accuracy of 86.50%, and a precision rate of 88%. These metrics demonstrate the effectiveness of the monument classification module. The research findings unequivocally show that our proposed monument recognition-based on satellite images system excels in determining the monument entered by the user.

Algorithms used:
Support Vector Machines (SVM)
Convolutional Neural Networks (CNN)

Algorithm	SVM	CNN
Testing Accuracy	0.65	0.86
Validation Accuracy	0.69	0.90

Both the models were able to detect the entered monument with reasonable accuracy, but CNN outperformed SVM. This is likely since CNNs are better at learning complex patterns in data, such as those found in the satellite images with the help of the convolutional layers.

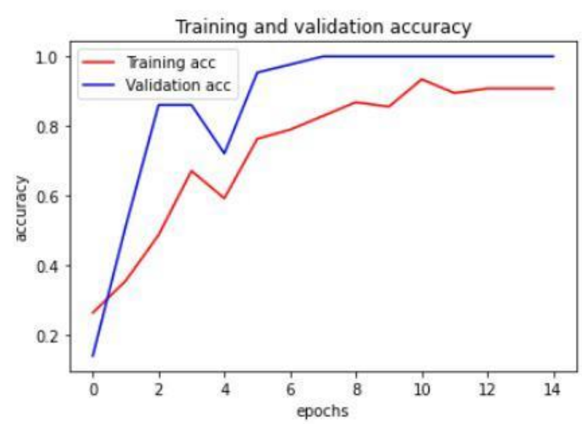

FIG 14

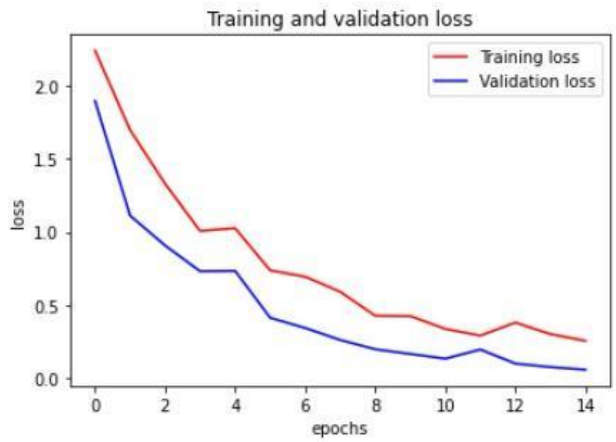

FIG 15

Hyperparameter	Values
Batch Size	32
No of classes	6
Optimizer	Adam
Learning rate	0.001
Epoch	30
Total	25
Activatation Function	ReLu, SoftMax
Loss Function	Categorical Crossentrophy
Metrics	Accuracy

```
test_loss, test_accuracy = model.evaluate(test_generator)
print(f"Test accuracy: {test_accuracy}")

2/2 [==============================] - 0s 44ms/step - loss: 0.5745 - accuracy: 0.8636
Test accuracy: 0.8636363744735718
```

FIG 16: Accuracy result

V.CONCLUSION AND FUTURE SCOPE

Our project " Heritage Identification of monuments using DeepLearning Techniques" can be used not only to raise awareness among the masses but can be used for preservation and restoration of monuments. The different archeological societies can utilize the system as well as the database for their work. The different technologies used in this project like SVM and CNN had a huge impact on this project. Moreover, this project can help touch a sector which was yet not explored or given much importance.

The open-source database that will be created with this initiative will not only help our project but can help countless other projects and have real life impacts including sectors like tourism.

Future scope of our project includes:

- For now, we are using a web-application but we plan on creating a mobile application and host it on sites like Heroku. In this way we can reach a lot more people and can have people use it with ease.

- The database as of now is still very small, we have to keep adding new monuments not only the famous ones but all of them and grow at a level that it can be used as a central repository. The open-source concept will help us to achieve in that.

- The databases are of India mostly, this needs to be global and people from all over the world should have access the database so that no border or geographical barrier stop people from learning about different sites.

ACKNOWLEDGMENT

We extend our heartfelt gratitude to our esteemed supervisor, Miss Shweta, whose guidance and insightful feedback played a pivotal role in shaping this research article. We also express our sincere thanks to the dedicated panelists who meticulously evaluated our work, offering invaluable perspectives and constructive critique.
We are deeply appreciative of Chandigarh University for providing us with a nurturing academic environment and resources essential for our research.
Our friends and parents deserve our profound appreciation for their unwavering support, understanding, and encouragement throughout this endeavor. Their belief in us has been our greatest motivation, and we are profoundly grateful for their presence in our lives.

REFERENCES

[1] Lowe, D. G. (2004). Distinctive image features from scale-invariant keypoints. International journal of computer vision, 60(2), 91-110.

[2] Badrinarayanan, V., Kendall, A., & Cipolla, R. (2017). SegNet: A Deep Convolutional Encoder-Decoder Architecture for Image Segmentation. IEEE Transactions on Pattern Analysis and Machine Intelligence, 39(12), 2481-2495.

[3] Krizhevsky, A., Sutskever, I., & Hinton, G. E. (2012). ImageNet classification with deep convolutional neural networks. In Advances in neural information processing systems, 1097-1105.

[4] Yosinski, J., Clune, J., Bengio, Y., & Lipson, H. (2014). How transferable are features in deep neural networks? In Advances in neural information processing systems, 3320-3328.

[5] Goodfellow, I., et al. (2014). Generative adversarial nets. In Advances in neural information processing systems, 2672-2680.

[6] Cireşan, D. C., Meier, U., & Schmidhuber, J. (2012). Multi-column deep neural networks for image classification. In 2012 IEEE Conference on Computer Vision and Pattern Recognition, IEEE, 3642-3649.

[7] Sun, Y., et al. (2017). Sparse feature learning for deep belief networks. Neural computation, 29(12), 3322-3352.

[8] Ge, Z., et al. (2018). Deep learning for environmental challenges. Nature Electronics, 1(3), 114-119.

[9] Vinyals, O., Blundell, C., Lillicrap, T., & Wierstra, D. (2016). Matching networks for one shot learning. In Advances in neural information processing systems, 3630-3638.

[10] Kounavis, C. D., Kasimatis, K. P., & Tzovaras, D. G. (2018). Augmented reality in cultural heritage: Field of application and case studies. Journal of Cultural Heritage, 34, 37-55.

[11] Kontogianni, G., et al. (2020). Deep learning for assessing the health of cultural heritage structures. Journal of Cultural Heritage, 45, 125-134.