Purpose of Project Work outline

The Project Work outline should give an overview of the work they intend to pursue for Project Work and present a time schedule of their planned tasks or milestone events.

The proposal submitted by the student will be evaluated by the institute. The evaluation would typically include the following issues.
1. Problem definition, clarity of the proposed work by the student and the proposed outcome of the work
2. Quality of work to qualify as Project Work
2. Justification for **16 weeks of work,** which is the assigned duration for Project Work
3. Proposed action plan for carrying out the work.

Once prepared and submitted it serves as the specification document for carrying out the work. If the outline is prepared with care and in detail with sufficient inputs, it will become a plan document and will aid the student to complete the tasks effectively within the stipulated duration.

The students are requested to prepare the outline keeping this in mind and submit it in the format prescribed in the "guidelines for Project Work outline", which is presented below in this document.

Once the outline is prepared the students may start working on the Project Work, without waiting for any approval by the institute. Modifications, if any, are required to be made. The Project Work feedback will be provided by the Institute within a period of two weeks.

I. Format of the Cover Page of the Dissertation

Deepfake Handwriting: Generating Forged Handwriting and Enhancing Detection with Limited Training Data

DISSERTATION

Submitted in partial fulfillment of the requirements of the

Degree : MTech in Artificial Intelligence and Machine Learning.

By

Sathish K S
2022AA05106

Under the supervision of

Anurag Pandey
(Associate General Manager)

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE
Pilani (Rajasthan) INDIA

June 2024

II. The following format for Dissertation Abstract should be used

BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI
SECOND SEMESTER 2023-24

DSECLZG628T / **AIMLCZG628T DISSERTATION**

Dissertation Title : Deepfake Handwriting: Generating Forged Handwriting and Enhancing Detection with Limited Training Data

Name of Supervisor : Anurag Pandey

Name of Student : Sathish K S

ID No. of Student : 2022AA05106

Courses Relevant for the Project & Corresponding Semester :

1. Advanced Deep Learning (3rd Semester)
2. Video Analytics (3rd Semester)
3. Deep Learning (2nd Semester)
4. Machine Learning (1st Semester)

Abstract

The spread of deepfakes requires robust detection systems. However, training such systems often requires considerable data, which can be scarce. This project addresses this challenge by creating deepfake biometrics, specifically focusing on handwriting. While deepfake generation for images and videos is well-studied, deepfake generation in the area of biometrics for handwritings remains understudied, especially with limited datasets. Here we use the latest advances in Masked Autoencoders (MAEs) and similar approaches to generate digital deepfakes with minimal data requirements.

Handwriting being done on e-pads is kind of time series (1-dimensional) data where the trajectory (X and Y coordinates w.r.t time) gets captured at regular intervals. Generation models like LSTMs (Long Short-Term Memory), Variational Autoencoders (VAEs), Generative Adversarial Networks (GANs) for Time Series (T-GANs) are capable of generating such timeseries data. Further, these 1-D data representations can be rendered to video representation by interpolating the X-Y coordinates using algorithms to use with the MAEs. This project explores both the approaches:

1. Video Masked Autoencoders (VideoMAE) using the Vision Transformer (ViT) backbone using the created video representations.
2. TrajectoryMAE, a new method replacing ViT backbone with 1D Convolutional Neural Network (CNN) backbone in Masked Autoencoder using the 1-dimensional data representation.

This project investigates the comparative effectiveness of these approaches in generating deepfakes and then training a robust handwriting deepfake detection system. Unlike conventional methods that rely on manually generated fakes for training detection systems, we propose a system-generated approach for enhanced robustness.

Key Words:

Deepfake Generation
Deepfake Detection
Deepfake handwriting
Biometric data
Handwriting
Video Data
1-dimensional data representation
Masked Auto Encoders (MAEs)
Video Masked Auto Encoders (VideoMAE)
Vision Transformers (ViT)
Limited data

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
II SEMESTER 23-24
DSECLZG628T / **AIMLCZG628T DISSERTATION**
Dissertation Outline

BITS ID No. **2022AA05106** **Name of Student:** **Sathish K S**

Name of Supervisor: **Anurag Pandey**

Designation of Supervisor: **Associate General Manager**

Qualification and Experience: **MTech (Software Systems) and 18 years of Exp.**

Official E- mail ID of Supervisor: **anurag.pandey@hcltech.com**

Topic of Dissertation: **Deepfake Handwriting: Generating Forged Handwriting and Enhancing Detection with Limited Training Data**

(Signature of Student) (Signature of Supervisor)

Date: 07 June 2024 Date: 07 June 2024

The following pages give basic guidelines regarding the Project Work requirement and the outline preparation.

Guidelines for Project Work outline document preparation

The student should prepare a detailed **outline** of the Project Work in consultation with his/her Supervisor. Current literature (journals, books etc.) may be reviewed to support your work.

Project Work Title

Title should reflect the work that is to be carried out and should not be a very general in nature.

Discussion on the chosen topic

This section should include:

1. The purpose of the work and expected outcome of the work
2. Literature review done in connection with the work, if applicable
3. Brief discussion on the existing process and its limitations
4. Justification for selecting a particular methodology for completing the tasks
5. Brief discussion on the Project Work methodology
6. Benefits derivable from the work
7. Any other details in support of the work

Detailed plan of work

In this section you are required to break down the Project Work into identifiable activities and give duration for each of these sub tasks, thus justifying for 16 weeks of work.

Format for the outline document to be submitted is presented in the following pages that has to be strictly followed.

Please note that: Outline document has to be uploaded on the viva portal.

1. Broad Area of Work

Deepfake generation and Detection in the area of Biometrics

2. Objectives

The objectives of my project are as follows:

- Explore methodologies to generate digital deepfake handwriting
- Evaluate the effectiveness of the methods
- Enhance the detection system to be more robust by training with not just the manual forged data, but also the system generated.

3. **Scope of Work**

Scope of this dissertation is to design and develop a system for generating and detecting deepfakes of handwriting in the field of biometrics, using variations of Masked Autoencoders methodologies with limited training data.

This project explores below approaches:
1. Video Masked Autoencoders (VideoMAE) using the Vision Transformer (ViT) backbone using the created video representations.
2. TrajectoryMAE, a new method replacing ViT backbone with 1D Convolutional Neural Network (CNN) backbone in Masked Autoencoder using the 1-dimensional data representation.

We choose these methodologies since MAE is effectively trained on limited dataset in self-supervised way.

This project aims to develop a system that can not only create deepfakes, but also detect them effectively by employing the digital system generated forged handwriting to train along with manual forged handwriting data.

This study potentially has applications like generation of handwritten documents for the system typed texts in users writing style or in robotics where humanoids can replicate user style of handwriting.

4· **Detailed Plan of Work (Sample)** (for 16 weeks)

The plan of work should have tangible weekly or fortnightly milestones and deliverables, which can be measured to assess the adherence to the plan and therefore the rate of progress in the work. The plan of work can be specified in the table given below:

Serial Number of Task/ Phases	**Tasks or subtasks to be done** (be precise and specific)	**Start Date- End Date**	Planned duration in weeks	Specific Deliverable in terms of the project
1	**Literature Review**	June 8th - June 21st	2	Annotated bibliography of relevant research papers Video generation using MAE and Deepfake techniques related to handwriting/ signatures.

2	**Dataset Collection and Analysis**	June 22nd - June 28th	1	Acquired datasets for handwriting and signature. Generated video datasets. Summary report on data exploration and pre-processing steps.
3	**Evaluation of Existing Video generation Models**	June 29th - July 12th	2	Evaluation report of different models in this area.
4	**Deepfake Generation: Handwriting generation Using VideoMAE**	July 13th - July 26th	2	Documented methodology for deepfake handwriting creation from videos using VideoMAE.
5	**Deepfake Generation: Handwriting generation Using TrajectoryMAE**	July 27th - August 16th	3	Documented methodology for deepfake handwriting creation from 1-D Data (X-Y trajectory co-ordinates)
5	**Comparative Study: VideoMAE vs. TrajectoryMAE**	August 17th- August 23rd	1	Report on the comparative performance of TMAE and VideoMAE for deepfake generation.
6	**Deepfake Detection System**	August 24th- September 6th	2	Documented deepfake detection system based on the best performing model. Evaluation report on the system's performance.
7	**Thesis Writing and Refinement**	Throughout the Project	Ongoing	Finalized dissertation document.

5. Literature References

The following are referred journals from the preliminary literature review.

[1] Zhan Tong,Yibing Song,Jue Wang,Limin Wang. "VideoMAE: Masked Autoencoders are Data-Efficient Learners for Self-Supervised Video Pre-Training" , 2022.

[2] Emre Aksan, Fabrizio Pece, and Otmar Hilliges. "Deepwriting: Making digital ink editable via deep generative modeling", 2018.

[3] Soumen Basu1, Mayuna Gupta, Chetan Madan, Pankaj Gupta, Chetan Arora. "FocusMAE: Gallbladder Cancer Detection from Ultrasound Videos with Focused Masked Autoencoders", 2024.

[4] Troy Luhman, Eric Luhman. "Diffusion models for Handwriting Generation", 2020.

Supervisor's Rating of the Technical Quality of this Dissertation Outline

EXCELLENT / GOOD / FAIR/ POOR (Please specify): ___EXCELLENT_____

Supervisor's suggestions and remarks about the outline (if applicable).

Date : 07 June 2024

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(Signature of Supervisor)

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