

RESEARCH PROPOSAL FORM

(also referred to as the 'Statement of Intent Form', or SOI)

To be submitted by the researcher to the Institute Research Sub-Committee (IRC)

Research Title:

Black and White Image Colourisation using Deep Learning Techniques

Institute name

Information Communication Technology

Course / Programme:

Bachelor of Science (Honours) in Software Development

Level and year of study

Level 6 Year 2

Main area of study being proposed:

To expand on previous research on colourisation of historical black and white images, this study will focus on historic images of both portraits and landscapes from wars which will be used to predict the various colours within an image. Using different deep learning algorithms such as Deep Convolutional Neural Networks (DCNNs), Memory-Augmented Networks and Generative Adversarial Networks, grayscale images can be colourised and compared, both programmatically and by issuing questionnaires/surveys, to determine which algorithm produces the best output.

Such examples of image colourisation are the following:

- Colourised Images from a dissertation of a previous MCAST student.



- [Greatest Events of WWII in Colour](#) (Shows colourised archive footage from WWII)





Name of Researcher: Fabian Muscat	Researcher's I.D. Number: 446102L
Signature of Researcher F. Muscat	Date of submission of Form 27/06/2022
Name of Tutor (or Recommended Tutor): Thomas Gatt	

Personal Motivation for the Choice of Research Theme.

Machine learning has been vastly used in many different aspects of arts and photography in the past few years, such as image restoration and artwork generation from photographs. Being a photography and machine learning enthusiast, this will be a great opportunity to build a prototype which automates the colourisation process of a grayscale image.

Outline of Key Literature and Theoretical Framework or Propositions.

Image colourisation has been vastly researched in the past few years and is a highly undetermined problem, which does not have one unique solution. Before deep learning, image colourisation was done manually by other people by either user-provided colour scribbles or a colour reference image. Having several publicly available coloured images, neural networks are able to automate this process by learning what colours naturally correspond to real objects (Vitoria, et al., 2020). Several algorithms have been used to automate this process, such as deep convolutional networks (DCNN), generative neural networks (GAN), U-Nets and memory augmented neural networks (MANN).

In a study conducted by (Yoo, et al., 2019), Conditional-GANs and MANNs are used to colourise images. The adversarial loss from the GAN together with the colour feature extracted from the memory module are used to generate coloured images. The memory network is distinguished from previous approaches based on the key and value. The generator of the Conditional-GAN uses a grayscale image and a colour feature from the memory network as a condition to generate an image to try and fool the discriminator by producing a realistic image.

(Hwang & Zhou, 2016) conducted a study in which Deep-CNNs were used to colourise black and white images. The image is converted to the *CIELUV* colour space, where the *L* channel is used as the input, and the *U* and *V* channels are the target values. The CNN generates two arrays corresponding to the *U* and *V* channels. The three channels are then concatenated to form the *CIELUV* colour space which will represent the predicted image.

In a study by (Joshi, et al., 2020), a custom dataset is created consisting of heritage, historical and cultural image repositories of Nepal. Pre-processing was first performed by collecting a random number of RGB and grayscale images which were used for the train and testing datasets. Low-resolution and degraded images were removed, then cropping and resizing was applied. The images were converted to the CIE $L^*a^*b^*$ colour space. The deep learning model used was the CNN, which takes pre-processed grayscale images as inputs. The *L* component is used as the input during training time, while the a^* and b^* components are the target values. The model generates two arrays corresponding to the a^* and b^* channels. The three channels are then joined together to form the CIE $L^*a^*b^*$ representation of the predicted image. The results obtained were good for images which have features such as the sky or river appearing clearly but performed poorly in other images which contained specific objects.

The study conducted by (Dahlmann, et al., 2021) quantises an image based on 313 possible AB pairs. The original RGB image is quantised into distinct bins where each pixel corresponds to one of the 313 bins. Each pixel is quantised by converting it to the $L^*a^*b^*$ colour space. Once the dataset is quantised, the weighting scheme from (Zhang, et al., 2017)'s approach is computed, giving a weight to each bin based on the rarity of the bin. The architecture used is adopted from (Zhang, et al., 2017)'s study for use on 64x64 images. A few changes are made to this architecture. The depth of the network outputs at each layer is reduced and one of the convolutional blocks is removed to reduce the number of trainable parameters in the model. Finally, an additional two transpose convolutional blocks were added at the end to up sample the output back to the original width and height. Like the previous paper, the L channel is taken as the input and the a^* and b^* channels are the target values. A series of comparison studies were performed to assess the performance of the model. The two datasets which were used to analyse were a dataset of celebrity faces and a dataset of colourful flowers. Since (Dahlmann, et al., 2021) uses a modified and simpler model architecture and trained for far less time, the results obtained were of a poorer quality. For the second experiment, better results were obtained for the celebrity and flowers datasets, with results comparable to the baseline.

Significance of the Study.

This study aims at automating the colourisation process of grayscale images, which if done manually by a human would take a considerable amount of time. This study will expand on previous research, which predicts colour from historical images. This study will not only focus on historic portraits but also grayscale landscapes from previous wars.

Hypotheses and/or Research Question/s

Hypothesis: By using different deep learning techniques to colourise images, a human comparable output can be generated and generate a result comparable to a that of a human.

Research Questions:

- Which deep learning techniques can be used to improve existing methods?
- What types of images are easier/more difficult to colourise?
- Under which conditions does the algorithm perform best?

Target Participants and Research Methods for Data Collection and Analysis

The target participants for this research will not involve any physical contact but data would be anonymously collected by means of questionnaires/surveys and no businesses will be involved in this study.

With regards to research methods for data collection and analysis, the following methods will be adopted:

- Grayscale images along with their ground-truths, which are available for the public will be collected as a dataset.
 - Some examples of datasets are the following:
<https://beeldbankwo2.nl/en/>, <https://ww2db.com/photo.php>
- Different algorithms will be implemented to colourise images. These algorithms will be trained using the dataset mentioned in the previous step.
- Once the algorithms have been trained and produce a good result, questionnaires/surveys will be issued to analyse the results of the different algorithms implemented.



Dissertation Project Plan.

[illegible]



Ethical Considerations.

Refer to *guidance points below*. You are also additionally required to read MCAST Document 074 'Research Ethics Policy and Procedure' that is available on the College website

Research shall be conducted in such a manner so as to avoid any psychological and physical harm to humans and animals and financial damage to organizations:

- 1. Only the supervisor and examiners will have access to any data gathered.*
- 2. Participants will remain free to withdraw from the study at any time without having to provide any reason. In the case of withdrawal, all the records and information collection will be deleted.*
- 3. The participant, who is the sole proprietor of the data provided, is granting that such data would be processed for this study purposes only.*
- 4. The data collection process will be a transparent process.*
- 5. All transcriptions and/or electronic recordings reflecting the data collected, once exhausted, are to be deleted*
- 6. Confidentiality, anonymity, and data protection procedures are to be ethically abided by.*
- 7. The researcher would provide a soft copy of the study to the participant, if required.*

Enter details here regarding possibility of issues regarding confidential personal data:

No personal data will be collected during the testing of the prototype. When collecting questionnaires/surveys, all participants will remain anonymous.

Enter details here regarding possibility of physical harm

No physical harm will be caused since any form of research for this study will be conducted on a computer.

Enter details here regarding possibility of moral harm:

No moral harm will be caused as this research focuses on machines learning and image processing of public data.

Enter details here regarding possibility of business harm:

The intention of this research will not cause any harm to businesses as no businesses need to be involved throughout the course of this research.

*Please see **Annex 1** for a sample Participant Information Letter and **Annex 2** for a sample Participant Consent Form. Student is to submit a copy of the proposed Participant Information Letter and Participant Consent Form where applicable. Both documents should be attached to the end of the SOI that is being submitted by the student.*

List of Key References:

1. Vitoria, P., Raad, L. and Ballester, C., 2020. Chromagan: Adversarial picture colorization with semantic class distribution. In *Proceedings of the IEEE/CVF Winter Conference on Applications of Computer Vision* (pp. 2445-2454)
2. Yoo, S., Bahng, H., Chung, S., Lee, J., Chang, J. and Choo, J., 2019. Coloring with limited data: Few-shot colorization via memory augmented networks. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition* (pp. 11283-11292)
3. Hwang, J. and Zhou, Y., 2016. Image colorization with deep convolutional neural networks. In *Stanford University, Tech. Rep.*
4. Joshi, M. R. et al., 2020. Auto-Colorization of Historical Images Using Deep Convolutional Neural Networks. *mathematics*, 8(12), p. 2258
5. Dahlmann, A. et al., 2021. Back to the Future: Building Upon Image Colorization via Classification.
6. Zhang, R. et al., 2017. Real-Time User-Guided Image Colorization with Learned Deep Priors. *ACM Transactions on Graphics (TOG)*, 9(4).
7. Pavia, M., 2020. Giving life to the past: colourisation of historical black and white photographs using deep learning techniques.

This section is to be filled in by the representative of the Institute Research Sub-Committee (IRC) prior to forwarding of this Form to the 'MCAST Research Ethics Committee' for final ethics approval:

Nature of Ethical Consideration	Outcome (Tick)	Comments/Advice
All ethical issues have been adequately tackled.		
Possibility of issues regarding misuse of data or some form of harm.		

Details of Representative to the Institute Research Sub-Committee.	
Name	Signature



Designation	Date
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Annex 1: Participant Information Letter

Sample:

Title of Research: _____

You are being invited to take part in a research study. Before you decide to participate, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information.

What is the purpose of the study?

This research is being undertaken on...

Why have I been chosen?

You have been chosen because...

Do I have to take part?

It is up to you to decide whether or not you take part. If you decide to take part you will be given this information sheet to keep and be asked to sign a corresponding consent form.

What will happen to me if I take part?

You will then be given a questionnaire on.../your data will be used.../your image will be used...

What are the possible disadvantages and risks of taking part?

There are no disadvantages or risks foreseen in taking part in the study.

What are the possible benefits of taking part?

By taking part you will be contributing to the development of a set of recommendations for...

What if something goes wrong?

If you wish to complain or have any concerns about any aspect of the way in which you have been approached or treated during the course of this study, please contact...(researcher is to give his/her MCAST email as a contact)

Will my details be kept confidential?

All information which is collected about you during the course of the research will be kept strictly confidential so that only the researcher carrying out the research will have access to such information and will not be shared with any other individuals. Participants should note that data/images collected from this project may be retained and published in an anonymized form. By agreeing to participate in this project, you are consenting to the retention and publication of data.

What will happen to the results of the research study?

The results will be written up into a dissertation for my final project of my Bachelor...

Who is organizing the research?

The research is conducted as part of a degree in ...

Who may I contact for further information?

If you would like more information about the research before you decide...(researcher is to give his/her MCAST email as a contact)

Thank you for your interest in this research...



Annex 2: Participant (or Guardian) Consent Form



MCAST

Sample:

Title of Research: _____

Name of Researcher: _____

Please initial box

1. I confirm that I have read and understand the Information Letter for the above study and have had the opportunity to ask questions. ☐
2. I understand that my/my charge's participation is voluntary and that I/my charge am/are free to withdraw at any time without giving any reason. ☐
3. I agree to allow my daughter/son/charge to take part in the above study. ☐

(Statement 3 is to be included only when guardians/parents are involved in giving consent)

Name of Participant/
Guardian

Date

Signature

Researcher

Date

Signature

1 for participant; 1 for researcher