Research Design 2

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Abstract*—This paper offers some additional guidelines for MCAST IICT 2nd year B.Sc. students on research paper writing. The abstract is the first paragraph that any researcher reads and thus you need to capture the essence of your research. Dedicate 1 sentence for the theme (subject matter), another for your project aim, one for the proposed solution, then for the general outcome of this project (positive/negative result/outcome), another for the technology used (Windows/Linux, Android/iOS, C#/Java, Unity/Unreal), finally for any technique used (Neural Networks, Pearl Noise, Market Basket Analysis, K-Means, HMM, Augmented Reality). Following is an example: *In this research we are tackling the automatic annotation of cast members and use of key props within movies. Movies tend to gather a huge fan gathering who dedicate a lot of time and resources for documenting the content, thus tools to automate processes such as the timeline when cast members appear, presents of props such as weapons and other forms of annotations are desired. In this research we propose the use of image processing techniques, namely Principal Component Analysis (PCA) and Convolutional Neural Networks (CNN) for the automatic annotation of actors' timeline and presence of weapons in the popular Tv series Game of Thrones (GoT). Our proposed solution managed to detect the targets in 85% of the cases and we identify situations where this is challenging and recommend future research directions.

***Index Terms*—MCAST, IICT, LaTeX, Project, Paper**

I. Chosen Research

A balanced difficulty plays a crucial part in shaping an enjoyable player experience in a video game. Many have tried to address this problem using popular emerging technologies. This research, therefore, aims to study the creation of in-game opponents via the use of Reinforcement Learning (RL) and Deep Reinforcement Learning (DRL) techniques for generating difficulty settings in a casual strategy game. It is hoped that this research will provide developers with a set of recommendations for the creation of effective difficulty settings that may be expanded upon in future works, such as with the use of Dynamic Difficulty Adjustment to provide an improved player experience.

This research is positioned in the following manner on the Research Onion

Cite Saunders?

- **Research Philosophy** - Pragmatism
- **Research Approach** - Deductive
- **Research Strategy** - Experimental Research
- **Choices** - Mixed-methods
- **Time Horizon** - Cross-sectional
- **Techniques and Procedures** - Prototype game extracting quantitative metrics and a qualitative focus group

Background...

This research presents the following hypothesis: By using versions of an RL agent trained at varying lengths, effective difficulty settings can be created in a strategy game.

The intent of this sequential mixed-methods study is to test the effectiveness of an RL agent to create an opponent with multiple difficulty settings, In the first phase, a prototype game played by a sample of participants will be used to measure the relationship between an agent set to a particular difficulty setting and the difference between final player and opponent scores. This will be followed by a qualitative focus group with the participants to better understand how players perceived the difficulty between difficulty settings.

II. Review of Research Methodology

The use of Deep Reinforcement Learning (DRL) agents in games has seen a steady increase in recent years. An influential study showing the potential of DRL agents is [1]. In this study, a DRL agent was trained to play several classic Atari 2600 games. This was achieved by supplying the agent with a high-dimensional visual input at a steady rate as an observation [1]. After the completion of training, evaluation was carried out by having the agent play multiple rounds of every game, then comparing its average performance to agents using other learning methods as well as an expert human player [1].

[1] did not study, however, games in which a computer opponent directly competes with a player. Other studies have tackled this scenario. One notable study was conducted in 2017 on the use of a DRL agent in the fighting game *Super Smash Bros. Melee* [2]. Instead of raw visual input, this agent was trained on a simpler setup of directly observing in-game variables concerning itself and its opponent, such as position, velocity, and action state [2]. This AI was trained using the "self-play" technique, in which it learnt by playing against past versions of itself. Evaluation on this agent was carried out having it play against professional players in two major tournaments [2].

In a competitive strategy setting, DRL has also seen success. One of the most notable examples of this in recent years is OpenAI Five in *Dota 2* [3]. This agent was also trained using self-play, similar to [2]. Training was significantly more complex however, as the agent needed to observe around 16,000 variables, and therefore took 180 days of training [3]. Also similar to [2], this agent was evaluated by examining

its performance in a professional competitive setting, playing against the world champion team in an Esports game [3].

It may be observed that the previous studies all based their research on existing games. Despite this, DRL and RL technologies can be implemented by developers in their own games. For developers using the *Unity* game engine, this is readily available through the Unity ML-Agents package. This has been used successfully in the methodologies of studies using DRL in fighting games [4], as well as board games [5].

The studies mentioned thus far, however, do not study DRL agents developed for multiple difficulty settings, focusing instead on the development of a single optimal agent. Studying this requires different approaches in methodology. A 2019 study attempted this on the first-person shooter game, *Unreal Tournament 2004* [6]. Training saw the agent duel against a native bot set on the hardest difficulty, throughout which, versions of the agent were periodically saved. Outside of training, this agent was set to dynamically switch between versions, attempting to find the ideal difficulty for its opponent [6]. Evaluation was performed by pitting the agent against native bots of every difficulty, but was not tested on human players, which the study recommended for future work [6].

Mention difficulty study against human players.

Once you have documented some background on the theme you need to focus on three key aspects: **Data set**; **Algorithms**; **Evaluation**. So you need to research existing data sets and document them. Say we want to explore accent recognition in audio/video clips, you would need to identify existing data sets and document first by enumerating then by comparing in a table layout such as in Table I. A useful tool for creation of tables is Truben's Table Tool[1]. When enlisting the data sets make sure you provide the proper citation. When comparing you need to identify the key features/factors/variable that are important for your subject matter.

1) The Accents of the British Isles (ABI-1) Speech Corpus, [7]
2) TIMIT Acoustic-Phonetic Continuous Speech Corpus, [8]
3) Common Voice Data Set, [9]
4) WSJCAM0 Corpus, [10]
5) The Speech Accent Archive, [11]
6) The Arctic CMU Audio Database, [12]
7) VoxCeleb2, [13]

TABLE I
DATA-SET COMPARISON. ACCENT: NATIVE (N); NON-NATIVE (NN)

Data set	Speakers	Utterances	Accents	Citations	Type
1	280	855	14	28	N
2	630	6,300	8	1,918	N
3	50,590	644,120	16	N/A	N & NN
4	140	4,400	4	346	N
5	2,140	2,140	>100	132	N & NN
6	18	1,150	4	458	N & NN
7	6,000	1,128,246	6	168	N & NN

[1]http://truben.no/table/

Next you need to provide an overview of what researchers have proposed and their key results. A survey or review paper would be ideal since these kind of papers would cover multiple techniques and provide good comparisons. Returning to our example of "Automatic cyber-bullying detection" consider the technique comparison documented in Table II. Note the structure used in this table, first you have the citation of the research, followed by the data set used, then the metric quoted for comparison, finally the relevant result.

TABLE II
STATE OF THE ART RESULTS

Study	Data set	Metrics	Results
[14]	Crime Investigation Forum	F1 Score	CDMS: 40.75% CDCSGF: 39.75%
[15]	Corpus for English and Dutch	F1 Score	English: 64% Dutch: 61%
[16]	Twitter	F1 Score	93.6%
[17]	Instagram	F1 Score	SVM Classifier: 95.00% Image Classifier: 68.08%
[18]	Formsrping	Accuracy	78.5%
[19]	Youtube	Accuracy	66.70%

The final recommended part in a good literature review is a review in the evaluation metrics used. It is not possible to cover all possible evaluation metrics but in most cases there is a classification problem, which would require something called a confusion matrix. Consider the problem of recognising and distinguishing an image of a cat from that of a dog. You will have a data set split into training and testing. Both will have the ground truth, what the image is actually showing. This ground truth, in the case of the training data set will be used for the creation of the Artificial Intelligence (AI) model, whilst the ground truth in the testing data set will be used to compare the predicted classification. The predictions are plotted in a confusion matrix as shown in Table III. The same table can be extended to have more than 2 categories such as introducing the mouse category. Then you need to cycle the focus for each category as shown in Table IV and Table V, then extract the key values namely:

1) **True Positives (TP)** - This refers to the correctly predicted positive values i.e. the value of both the actual class and predicted class is yes.
2) **True Negatives (TN)** - These are the correctly predicted negative values i.e. the value of both actual class and predicted class is no.
3) **False Positives (FP)** - It indicates values where the actual class is no but the predicted class is yes.
4) **False Negatives (FN)** - It indicates values where the actual class is yes but the predicted class in no.

The confusion matrices are used to provide evaluation metrics such as Accuracy, Precision, Recall and F1-Score. Depending on the subject matter being researched the proper metrics need to be quoted, thus the need to research this in academic literature. For a quick but reliable reference you can consider Wikipedia's dedicated page[2].

[2]https://en.wikipedia.org/wiki/Confusion_matrix

TABLE III
SAMPLE CAT VS DOG CONFUSION MATRIX

		Predicted	
		Cat	Dog
Actual	Cat	33	2
	Dog	5	30

TABLE IV
CAT CATEGORY EVALUATION METRICS

		Predicted	
		Cat	Not-Cat
Actual	Cat	TP	FN
	Not-Cat	FP	TN

1) **Accuracy (ACC)** - This shows the measure of effectiveness of the machine learning model.

$$Accuracy(ACC) = \frac{TP + TN}{P + N} \tag{1}$$

2) **Precision (PPV)** - Precision is the ratio of correctly predicted positive values to the total predicted positive values. This metric highlights the correct positive predictions out of all the positive predictions. High precision indicates low false positive rate.

$$Precision(PPV) = \frac{TP}{TP + FP} \tag{2}$$

3) **Recall (TPR)** - The recall is the ratio of correctly predicted positive values to the actual postive values. Recall highlights the sensitivity of the algorithm i.e. out of all the actual positives how many were caught by the program.

$$Recall(TPR) = \frac{TP}{P} \tag{3}$$

4) **F1 Score** - F1 Score is the weighted average of Precision and Recall. Therefore, this score takes both false positives and false negatives into account. Intuitively it is not as easy to understand as accuracy, but F1 is usually more useful than accuracy, especially if you have an uneven class distribution.

$$F1Score = \frac{2TP}{2TP + FP + FN} \tag{4}$$

III. RESEARCH METHODOLOGY

This section is one of the most important parts of your research and it is the one that will receive most criticism. The reason is that here you document how you conducted your research. Since you are reading a B.Sc. degree you are expected to follow a scientific method, thus in this section you are expected to document: **the problem**; **hypothesis**; **aim & objectives**; **research questions**; and **research pipeline**. Let's go through each.

First start by providing a brief overview of the problem, similar to what you already mentioned in the previous sections. Then provide a hypothesis, this is the assumption you are making, which via your research you are attempting to prove or disprove. An example hypothesis in traffic management would be: *By using image processing on public camera video feeds we believe that it is possible to estimate the traffic congestion at a higher precision than public traffic data feeds.*

After explaining the problem and hypothesis you need to specify why you are doing this research and what you think the output will be, so the aim & objectives. Let us consider the "Marine Vessel Tracking" concept: *With this research we aim to be able to automatically detect any anomalies within Marine traffic, such as drug smuggling, human trafficking and/or collisions.* Our objectives are:

1) Identify existing data sets and manners of connecting them or even enriching them.
2) Review existing algorithms and propose a suitable model
3) Evaluate the effectiveness of the proposed model with real data and existing research.

So lastly you have to present a number of research questions that you attempt to answer, which ideally revolve around the **data set**, **algorithm** and **evaluation** which you documented in your literature review:

1) Does a data set need to be created for such a research?
2) Which current technology is best suited to address the problem?
3) How does the proposed solution compare with existing solutions?

Finally, you need a plan on how you intend to answer the research questions which will help you prove/disprove the hypothesis. Different research areas would require specific pipelines, yet a generic one is shown in Fig 1. After presenting an illustration of your pipeline it is recommended to documenting what has been done at every stage. Remember you should use past tense in this section since you are document what you have already done, since this paper will be published at the end of your research.

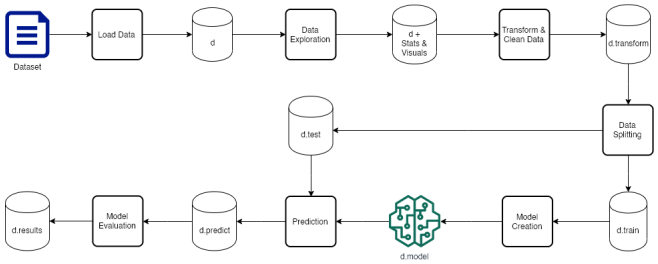

Fig. 1. Research Pipeline

TABLE V
DOG CATEGORY EVALUATION METRICS

		Predicted	
		Not-Dog	Dog
Actual	Not-Dog	TN	FP
	Dog	FN	TP

IV. FINDINGS & DISCUSSION OF RESULTS

This section is a delicate section and you are encouraged to be as honest and open as possible. The aim is not to show

that you got a perfect solution to a long existing problem. Trying to state that in a few months you developed a perfect solution with 100% is not convincing and raises doubts. It is recommended that you document your findings in every step of your research pipeline, highlighting your observations and decisions taken. Present your results and very importantly compare with existing research which you documented in Section II.

The focus of the Project module is for you to delve into an area that exposes you to new technologies and offers you an opportunity to be critical of your work. So you are expected to document where your solution/research worked and where it did not. Reflect and document reasons why the solution/research did not perform as expected and propose ways of addressing this. From these observations you will produce new research questions in the next section. Consider the research in "Brand usage detection within audio streams", where certain key terms were searched within videos, the results of which are documented in Table VI. You will notice that the terms "Peppa" and "Sushi" were the least recognised terms even by the best transcribers. Upon investigation we determined that "Peppa" was not recognised cause of voice morphing to create childish voices in the cartoon video, whilst "Sushi" was pronounced by a Japanese person speaking English. So the research student decided to focus his dissertation research on how to create a system that is able to recognise heavy accents to automate the configuration of a transcriber, in this case to cater for English spoken by a Japanese person, which accent is very different from an Indian accent, British accent or Italian accent, just to name a few.

TABLE VI
RECALL RESULTS

#	Term	Google Cloud	Google Speech	Sphinx CMU
1	Peppa	27%	33%	0%
2	Peppa	33%	22%	0%
3	Apple	96%	92%	79%
4	Galaxy	100%	100%	100%
5	Galaxy	95%	95%	80%
6	Sushi	75%	35%	0%
	Average	71%	62%	43%

V. CONCLUSION

So the conclusion is most probably the second section that a reader would use to consider reading in full your research. Thus it is important to highlight the essence of your research. The recommended approach is to answer your research methodology. Start by answering your research questions, then stating to what degree did this research achieve its aim and objectives, highlighting potential causes for not being able to do so at a desired level, such as time, or other circumstances. Consider the following: *A student was due to research the use of MCAST computers during out-of-office hours to offer a private cloud computing service for research, similar to Google Cloud but free for MCAST students. Due to the lockdown by COVID-19 pandemic we could not continue on the original planned research objective and had to adapt.*

The final and most important part of the conclusion are your recommendations for future research, not necessarily for yourself (referring to what you plan to do in your dissertation or beyond), but also to other future researchers who might consider doing similar work to yours. The recommendations you provide here will set such prospective researchers on a better track/direction thanks to your experience.

APPENDIX A
SUPPORTING MATERIAL

You can add screen shots and statistics. Stick to essential information.

ACKNOWLEDGEMENT

You can dedicate this section for special assistance that you were given by a 3rd party. Not your mentor, relatives or questionnaire participants.

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