

## **COMP30040 Report**

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# Contents

<b>Contents</b>	<b>2</b>
<b>List of Figures</b>	<b>4</b>
<b>List of Tables</b>	<b>4</b>
<b>Abbreviations and Acronyms</b>	<b>4</b>
<b>Abstract</b>	<b>5</b>
<b>Declaration of originality</b>	<b>6</b>
<b>Intellectual property statement</b>	<b>7</b>
<b>Acknowledgements</b>	<b>8</b>
<b>1 Introduction</b>	<b>9</b>
1.1 Background and motivation	9
1.2 Aims and objectives	9
1.3 Report structure	9
<b>2 Background and Literature Review</b>	<b>9</b>
2.1 Overview of Related Systems	9
2.1.1 Vinyl Systems	9
2.1.2 Image Recognition	9
2.2 Legal and Ethical Considerations	10
2.2.1 Copyright Law and Fair Dealing	10
2.2.2 Use of Artworks in Model Training	10
2.2.3 Legal Compliance in Dataset Sourcing	11
2.2.4 Ethical Considerations	12
2.2.5 Conclusion	13
<b>3 Design</b>	<b>13</b>
3.1 Requirements Analysis	13
3.2 System Architecture	13
3.2.1 Technology Stack	13
3.2.2 Design Choices	14
3.3 Front-end	14
3.3.1 Primary User Interface	14
3.3.2 Audio Playback	14
3.3.3 Remote Clients	14
3.4 Back-end	15
3.4.1 Metadata Retrieval	15
3.4.2 Hardware Interaction	15
3.5 Machine Learning Model Design	15
3.5.1 Dataset Collection	15

3.5.2	Model Architecture . . . . .	15
3.6	Security Considerations . . . . .	15
3.7	Testing Methodology . . . . .	15
3.7.1	Validation of Effectiveness . . . . .	15
3.7.2	Validation of Affectiveness . . . . .	15
<b>4</b>	<b>Implementation . . . . .</b>	<b>15</b>
4.1	Front-end . . . . .	16
4.1.1	Challenges Encountered . . . . .	16
4.2	Back-end . . . . .	16
4.2.1	Challenges Encountered . . . . .	16
4.3	Hardware . . . . .	16
4.3.1	Challenges Encountered . . . . .	16
4.4	Machine Learning Model . . . . .	16
4.4.1	System Integration . . . . .	16
4.4.2	Challenges Encountered . . . . .	16
<b>5</b>	<b>Results . . . . .</b>	<b>16</b>
5.1	Software Artefact . . . . .	17
5.2	Hardware Artefact . . . . .	17
<b>6</b>	<b>Evaluation . . . . .</b>	<b>17</b>
6.1	Machine Learning Model Performance . . . . .	17
6.2	User Experience . . . . .	17
6.3	Comparison with Existing Systems . . . . .	17
6.4	Ethical Implications . . . . .	17
<b>7</b>	<b>Conclusions and future work . . . . .</b>	<b>17</b>
7.1	Conclusions . . . . .	17
7.2	Future work . . . . .	17
	<b>References . . . . .</b>	<b>17</b>
	<b>Appendices . . . . .</b>	<b>19</b>
<b>A</b>	<b>Project outline . . . . .</b>	<b>19</b>
<b>B</b>	<b>Risk assessment . . . . .</b>	<b>19</b>

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## List of Figures

## List of Tables

## Abbreviations and Acronyms

**AI** Artificial Intelligence

**API** Application Programming Interface

**CD** Compact Disc

**CDPA** Copyright, Designs and Patents Act 1988

**CNN** Convolutional Neural Network

**OCR** Optical Character Recognition

**ML** Machine Learning

**ToS** Terms of Service

**TOU** Terms of Use

## **Abstract**

Vinyl is back!

## **Declaration of originality**

I hereby confirm that this dissertation is my own original work unless referenced clearly to the contrary, and that no portion of the work referred to in the dissertation has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

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## Acknowledgements

I would like to extend my gratitude to the noble mahogany tree, whose sacrifice provided not only the material for a Welsh love spoon - by which I proposed and became engaged to my beloved fiancée - but also the offcuts that found purpose in the physical interface of this project. Your contribution to both my personal and academic life has been truly invaluable.

Also, to my close friend Joshua Bond's dissertation [1], which I have yet to fully read- but I am sure it is great.



# **1 Introduction**

## **1.1 Background and motivation**

## **1.2 Aims and objectives**

## **1.3 Report structure**

This report consists of seven chapters:

**Chapter 1** presents an introduction to the project.

**Chapter 2** presents the background behind this project, ...

**Chapter 3** presents details on the design ...

**Chapter 4** presents details on the implementation ...

**Chapter 5** presents the results ...

**Chapter 6** presents an evaluation ...

**Chapter 7** presents a discussion of the conclusion, limitations, and possible improvements of the project.

# **2 Background and Literature Review**

## **2.1 Overview of Related Systems**

### **2.1.1 Vinyl Systems**

Research into questions such as 'why do people like vinyl so much?' and 'why is it making a comeback?'. Traits distilled from this feed into later design choices (I have chosen to make a physical artefact with a mahogany base, because physicality and aesthetics are important the people who would potentially use this system).

### **2.1.2 Image Recognition**

Papers that inform the use of different approaches, etc. CNN vs OCR, etc.

## 2.2 Legal and Ethical Considerations

The training and use of machine learning models for image classification requires the acquisition and processing of data, which, in order to effectively handle the cover art of existing albums, necessitates obtaining and using their copyrighted artworks. This raises both legal and ethical concerns, particularly regarding compliance with UK copyright law and exemptions. This section examines the legal basis for dataset usage, fair dealing exemptions, and the ethical implications of using copyrighted material in an academic AI project.

### 2.2.1 Copyright Law and Fair Dealing

Under the *Copyright, Designs and Patents Act 1988* [2], creative works, including album covers, are protected from unauthorised use, reproduction, distribution, and modification.

However, UK law also provides a key exception known as Fair Dealing, which allows limited use of copyrighted material under specific conditions. Although such exemptions are only granted under very specific circumstances and for a very limited scope of use. Importantly, it is not a rigid rule but a context-dependent legal doctrine, evaluated on a case-by-case basis. The law does not explicitly define what qualifies as fair dealing; instead, courts assess whether a use is reasonable and justified based on the combination of several established legal factors.

One of the most relevant exemptions is non-commercial research, as outlined in *Section 29(1)* of the CDPA:

*Fair dealing with a work for the purposes of research for a non-commercial purpose does not infringe any copyright in the work provided that it is accompanied by a sufficient acknowledgement. [2]*

This indicates that non-commercial academic research can be exempt from copyright infringement if proper attribution is provided. However, the applicability of this exemption depends on further and additional factors, such as the amount of material used and its impact on the copyright holder's market.

### 2.2.2 Use of Artworks in Model Training

Album covers are protected by copyright as highly creative works. Any reproduction or modification is typically restricted without permission from the copyright holder. As such, the bar needed for fair dealings is very high when dealing with such artwork. However, training a classification model may qualify for fair dealing, provided certain conditions are met.

A key legal question is whether machine learning training qualifies as “*computational analysis*” under *Section 29A* of the CDPA, which states:

*(1) The making of a copy of a work by a person who has lawful access to the work does not infringe copyright in the work provided that—  
(a) the copy is made in order that a person who has lawful access to the work may carry out a computational analysis of anything recorded in the work for the sole purpose of research for a non-commercial purpose, and  
(b) the copy is accompanied by a sufficient acknowledgement (unless this would be impossible for reasons of practicality or otherwise). [2]*

This expresses that there is a strong argument for legal use of copyrighted materials in creating a computational model which classifies data by comparisons of analytically-derived embeddings.

It is, however, important to consider whether image processing qualifies as analysis under this law or whether this interpretation is too broad, given that past applications of computational analysis have predominantly involved text, and that image processing of this kind is still relatively new. Since there is no clear legal precedent on this specific topic, further legal clarification would be necessary to definitively confirm or deny its applicability to image-based AI models.

It also reiterates the need for attribution, but, notably states that this is only required in cases where it is feasibly practical.

Given these factors, classification likely qualifies under Fair Dealing because the model does not generate new images but merely classifies existing ones. This distinction is important, especially given recent legal scrutiny of generative AI models like OpenAI's Dall-E, which create derivative works rather than merely labelling.

### **2.2.3 Legal Compliance in Dataset Sourcing**

Beyond Fair Dealing considerations, data sourcing must be legally compliant. According to *Section 29A [2]*, only individuals with lawful access to copyrighted works may use them for computational analysis. Therefore, it is essential to determine how these images can be legitimately acquired.

Machine learning models must fully process training images in their entirety to generate a model. This requires the whole image to be either stored persistently (on disk) or temporarily (in memory). Even if the image is only ever stored and processed in chunks (similar to how streaming providers serve video data), the overall image is eventually processed by the model. *Section 28A* outlines more leniency for cases where only temporary copies are stored, for lawful access.

It is also important to consider if entire images are required, as opposed to only sections of them. If it would be possible to achieve the desired result using only subsets of the acquired dataset, then more data would be stored and used than is justified. The legal precedent *Ashdown v Telegraph Group Ltd (2002)*, highlights that:

*The third most important factor is the amount and importance of the work that has been taken . . . in some circumstances the taking of an excessive amount, or the taking of even a small amount if on a regular basis, would negative fair dealing. [3]*

Thus, ensuring only necessary data is used is critical for compliance.

In addition to just the handling of the data, however, its source must also be considered. There are three methods by which the training dataset could be acquired: by fetching data from an API, by scraping the data from the web, or, by manually taking the required photos (either by just me, personally, or by crowd-sourcing the images). Realistically, the first two options are most practically feasible.

There are many vendors of the cover arts of music albums. Notably, music vendors (such as *Spotify*) and music collection and review sites (such as *Discogs*) provide the album arts in a structured format where the artworks are synchronised with the albums which they belong to. However, due to the recent boom of generative AI models - and the controversy surrounding them - many vendors have explicitly prohibited the use of their data for machine learning in their Terms of Services.

*Do not use the Spotify Platform or any Spotify Content to train a machine learning or AI model or otherwise ingest Spotify Content into a machine learning or AI model.*

[4] (III.14)

*Do not misuse the Spotify Platform, including by i. using the Spotify Platform or any Spotify Content to train a machine learning or AI model or otherwise ingesting Spotify Content into a machine learning or AI model;*

[5] (IV.2.a.i)

*[Discogs] strictly prohibit (1) the development of any software program, including, but not limited to, training a machine learning or artificial intelligence (AI) system using the Service content*

[6] (LICENSE AND SITE ACCESS)

However, if a site has more permissive policies, allowing the training of AI models, then, as long as the images are handled appropriately, they can be lawfully accessed and used.

## 2.2.4 Ethical Considerations

Even if it is legally permissible to source and use these images, it is also important to consider whether or not it is ethically responsible. These images, at the end of the day, are the highly creative works artists, whose livelihoods come from their creations. Reproducing (by downloading) and using their works therefore cannot be done without serious moral consideration.

Most significantly, it is worth noting that this AI model is not generative (which is where most of the recent controversies stem from), and therefore, instead of producing its own artworks based off of the images fed to it, it simply classifies them by labelling them with its prediction of their corresponding album. Therefore, whilst the model is technically derived from the artist's works, the produced work is not in competition with the additional artists, and therefore should not have a negative impact on their commercial success. If anything, it is argued that this system should benefit

them, by encouraging the purchasing of physical media, and garnering instances of playing their content on a revenue-generating service.

Furthermore, as this does not share or distribute the images themselves with the users, I believe it to be even more safe, as the only artefact generated from these images are a classification system which can be used by the user, but even the numerics themselves are not made accessible to the user.

And, whilst the law allows for the exclusion for explicit attribution of all involved copyright holders, this may not be ethical. However, as this is a classification system, it arguably gives some degree of implicit accreditation to the artworks used in the training process, when the predicted label is used to redirect the user to said album.

### **2.2.5 Conclusion**

This section examined the legal and ethical implications of using copyrighted album covers in machine learning. Based on UK Fair Dealing exemptions in the CDPA 1988, I would argue that there is a solid grounding this project likely qualifies as a legally permissible use case, provided:

- It is a non-commercial, research project.
- Data is lawfully acquired from permitting sources.
- The dataset scale and usage is minimised to strictly what is necessary.
- None of the images are shared or modified.

From an ethical standpoint, the project is distinguishable from controversial generative AI models, as it does not replace artists' work or impact their revenue streams. Nonetheless, transparency and attribution best practices should be followed.

## **3 Design**

What did past-Jack set out to do?

### **3.1 Requirements Analysis**

### **3.2 System Architecture**

#### **3.2.1 Technology Stack**

All of the technologies used (TS, React, bun, Python, FastAPI, etc.), and why them specifically.

### **3.2.2 Design Choices**

Particular broad and niche design choices made, and why, such as:

1. Why use a web approach for a localised device?
2. Why use an unorthodox 1-1 Websocket approach for client-server calls?

Also things such as 'point of truth handling', etc.

Design philosophy of being as non-reliant on Spotify (or any other singular API) as possible

## **3.3 Front-end**

### **3.3.1 Primary User Interface**

Minimal-UI approach

Physical user interaction controls

### **3.3.2 Audio Playback**

### **3.3.3 Remote Clients**

'Remote Control' UI from an external device (mobile, etc.)

Gains that this system provides: accessibility (mobility, etc), convenience, scanning of out-of-house albums, etc.

## **3.4 Back-end**

### **3.4.1 Metadata Retrieval**

### **3.4.2 Hardware Interaction**

## **3.5 Machine Learning Model Design**

### **3.5.1 Dataset Collection**

### **3.5.2 Model Architecture**

## **3.6 Security Considerations**

## **3.7 Testing Methodology**

Design of tests and evaluations; plan for unit testing, model evaluation, etc.

Does the system satisfy that physical and aesthetic desires of that the vinyl trend appeals to, whilst still offering functional convenience over original systems?

### **3.7.1 Validation of Effectiveness**

1. Model performance (formal model evaluation)
2. Usability (user feedback)
3. Code robustness (Unit Tests, etc.)

### **3.7.2 Validation of Affectiveness**

User feedback on aesthetics

## **4 Implementation**

Details realised in practice, decisions made, etc.

Challenges encountered, how addressed, etc.

## **4.1 Front-end**

### **4.1.1 Challenges Encountered**

1. Switch to minimal UI mid-production 2. Responsive / wholeness tradeoff (do we wait for the centre label before playing the audio?) 3. Media codec, DRM, etc. issues specific to Ubuntu/aarch64 OS.

## **4.2 Back-end**

### **4.2.1 Challenges Encountered**

1. Change of auth flow, due to 'remote client' introduction 2. Removal of barcode detection from spec, due to camera limitations

## **4.3 Hardware**

### **4.3.1 Challenges Encountered**

1. Lack of 'Measure twice, cut once' methodology (fried GPIO pin; overstrained motor driver) 2. Voltage issues 3. Overheating (throttling) issues

## **4.4 Machine Learning Model**

### **4.4.1 System Integration**

Practice-driven discoveries, such as 'how much is not too much' when it came to model architecture and the Pi's specs.

### **4.4.2 Challenges Encountered**

Internet Archive downtime!

## **5 Results**

What was actually produced?



## **5.1 Software Artefact**

## **5.2 Hardware Artefact**

# **6 Evaluation**

## **6.1 Machine Learning Model Performance**

## **6.2 User Experience**

## **6.3 Comparison with Existing Systems**

## **6.4 Ethical Implications**

# **7 Conclusions and future work**

## **7.1 Conclusions**

## **7.2 Future work**

# **References**

- [1] J. Bond, *Visualising Jesus: The appropriation and rejection of pagan divinity in pre-Constantinian images of Christ*, CLASS3200: Major Research Project, Supervisor: Samuel Gartland, 2024 (cited on p. 8).
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- [3] H. Laddie, P. Prescott, and M. Vitoria, *The Modern Law of Copyright and Designs*, 3rd. Butterworths, 2000, Cited in *Ashdown v Telegraph Group Ltd* [2002] Ch 149, at [20.16] (cited on p. 11).
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- [5] Spotify, *Spotify developer terms*, Version 9, effective as of 8 May, 2023, 2023. [Online]. Available: <https://developer.spotify.com/terms> (cited on p. 12).

- [6] Discogs, *Terms of service*, Accessed 18 Nov. 2024, 2024. [Online]. Available: <https://support.discogs.com/hc/en-us/articles/360009334333-Terms-of-Service> (cited on p. 12).

## **Appendices**

### **A Project outline**

Project outline as submitted at the start of the project is a required appendix. Put here.

### **B Risk assessment**

Risk assessment is a required appendix. Put here.