Media Engineering and Technology Faculty
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Feature Extraction from Sketch Based Images

Interim Report 1

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Chapter 1

Introduction

This thesis aims to explore the potential of a system that can extract features from hand-drawn sketches and search for related images from a dataset based on the extracted features[1] The system leverages machine learning algorithms to analyze and identify features such as lines, shapes, and curves[2] The goal is to provide designers and artists with a tool that streamlines the creative process and helps them find related images based on their sketches. This system has the potential to revolutionize the design process across various fields, including architecture, art, and engineering. The thesis delves into the technical challenges involved in developing the system, including the design of feature extraction algorithms and machine learning models for image recognition. It evaluates the performance of the system in terms of accuracy and efficiency, and compares it to other similar systems in the literature. Overall, this thesis contributes to the field of design by presenting a new tool that can assist designers and artists in their creative work.

1.1 Motivation

Sketch-based images are an essential part of the design process and a powerful means of representing visual information. However, extracting meaningful features from sketch-based images can be challenging due to their abstract and less detailed nature compared to other types of images. This poses a unique challenge when it comes to identifying and extracting features from such images. Despite these challenges, feature extraction from sketch-based images is an important area of research for several reasons. Firstly, it can help artists and designers find related sketches or images based on their own sketches, providing them with inspiration and guidance for their work. Secondly, it can aid in the creation of mood boards or design proposals, enabling designers to explore different variations and interpretations of their design. Finally, it can be used in educational settings, allowing students to learn about different design styles and techniques by searching for related sketches and images. By addressing these challenges and developing a system that can accurately and efficiently extract features from sketch-based images, this thesis seeks to contribute to the field of design and provide a new and innovative solution to a longstanding challenge.[3][4]

1.2 Problem Statement

Extracting meaningful features from hand-drawn sketches is a challenging task due to the abstract and less detailed nature of such images. The main problem with feature extraction from sketch-based images is the lack of well-defined edges and textures, which makes it difficult to distinguish between different objects and their components. Additionally, the complexity and variability of sketches make it challenging to identify the relevant features that can be used for further analysis and interpretation. As a result, the accuracy and effectiveness of machine learning algorithms for analyzing and interpreting sketch-based images are limited, which hinders their potential use in various fields such as design and education. This thesis aims to address these challenges by developing an applied system that can accurately and efficiently extract features from hand-drawn sketches, enabling more effective search and analysis of related images in a dataset.[5]

1.3 Objectives

The objectives of this work are:

- Develop a system that can extract meaningful features from hand-drawn sketches using machine learning.
- Evaluate the system's performance in extracting features from a variety of sketches and compare it with existing methods.
- Enable the system to search for related images in a dataset based on the extracted features.
- Evaluate the system's performance in searching for related images based on hand-drawn sketches, and compare it with existing methods.
- Demonstrate the potential applications of the developed system in design and education, and identify areas for further research and development.

Chapter 2

Current Status

2.1 Completed Objectives

- Researched the topic of feature extraction from sketch-based images (SBIR):
  - Conducted a thorough literature review on the topic of SBIR and feature extraction techniques.
  - Explored various research papers, articles, and online resources to gain a comprehensive understanding of the topic.
  - Gathered information about different feature extraction techniques, their advantages and disadvantages, and their applications in the field of SBIR.
  - Analyzed various case studies to understand the real-world applications of SBIR and feature extraction techniques.
- Completed the deep learning section of a machine learning course:
  - Studied the foundational concepts of deep learning, including neural networks, activation functions, loss functions, optimization algorithms, and regularization techniques.
  - Learned about various types of neural networks, including artficial neural networks, convolutional neural networks (CNNs).
  - Explored popular deep learning frameworks, such as TensorFlow and learned how to use them to implement neural networks.
  - Practiced implementing neural networks for different applications.
- Downloaded and installed the QuickDraw dataset from Google:
  - Explored the QuickDraw dataset and learned about its structure and contents.
  - Downloaded the dataset and set up the necessary infrastructure to use it for training a CNN model.

- Preprocessed the dataset to clean and normalize the data and prepare it for use in the CNN model.
- Verified that the dataset was downloaded and preprocessed correctly and that it contained enough data to train a CNN model.

2.2 Remaining Objectives

- Finish Training the CNN Model:
  - Design and implement a convolutional neural network (CNN) model for feature extraction from sketch-based images
  - Train the CNN model using the QuickDraw dataset
  - Monitor the training process and adjust hyperparameters as needed
  - Evaluate the performance of the trained CNN model using appropriate metrics
- Implementation of CNN Model in a Web-Based Application:
  - Develop a web-based application that can take sketch-based images as input
  - Integrate the trained CNN model into the web application for feature extraction
  - Implement appropriate visualization techniques to display the extracted features
- Testing:
  - Perform various tests on the web-based application to ensure it is functioning properly
  - Test the CNN model's accuracy and efficiency using different datasets and scenarios
- Tweaking:
  - Analyze the performance of the CNN model and web application to identify areas for improvement
  - Make necessary adjustments to the CNN model's architecture, hyperparameters, or training process to improve its accuracy and efficiency
  - Make necessary adjustments to the web-based application's design or functionality to improve user experience and overall performance.

Chapter 3

Literature Review

3.1 Introduction

Sketch-based image retrieval (SBIR) is a rapidly evolving research area that has attracted increasing attention in recent years due to its potential applications in various fields such as design, architecture, and robotics. SBIR is a technique that enables users to retrieve images by sketching rather than using textual queries. One of the key challenges in SBIR is how to extract useful features from the user's sketch to enable effective image retrieval. Feature extraction is a crucial step in the SBIR pipeline, as it is responsible for transforming the user's sketch into a numerical representation that can be used to retrieve relevant images from a database.

The process of feature extraction from sketches involves several complex tasks, such as stroke segmentation, feature selection, and feature encoding. Researchers have proposed various techniques to address these challenges, including deep learning-based approaches, which have shown promising results in recent years. For instance, Qian et al. (2021) [6] proposed a novel feature extraction method for SBIR based on a convolutional neural network (CNN) architecture that extracts features from both the sketch and the image to improve retrieval performance. Similarly, Wang et al. (2020) [7] proposed a sketch-based image retrieval method that utilizes a multi-scale residual network for feature extraction, achieving state-of-the-art performance on several benchmark data sets.

However, despite the significant progress in this field, there are still many open research questions and challenges that need to be addressed to enable more accurate and efficient sketch-based image retrieval. For instance, the choice of feature extraction technique can greatly impact the retrieval performance, and different techniques may be better suited for different types of sketches or images. In addition, the interpretation and visualization of the extracted features can be challenging, and there is a need for more interpret-able feature extraction techniques.

In this literature review, we aim to provide a comprehensive overview of the current state-of-the-art techniques for feature extraction in SBIR. We will review the literature on various approaches for feature extraction, including traditional handcrafted feature-based methods and deep learning-based approaches. We will also discuss the challenges and limitations of these approaches and identify potential research directions for future work. By synthesizing and analyzing the relevant literature, we hope to provide a deeper understanding of the current state of the art in feature extraction for SBIR and help guide future research in this exciting and rapidly evolving field.

3.2 Search Criteria and Methods

To conduct this literature search, we used a variety of academic search engines and databases, including Google Scholar, ACM Digital Library, IEEE Xplore, Springer, and ScienceDirect. We used a combination of search terms related to feature extraction and SBIR, such as "feature extraction", "feature selection", "deep learning", "sketch-based image retrieval", and "SBIR". We limited the search results to academic papers published in peer-reviewed journals or conference proceedings from 2010 to 2023.

The selected papers cover a range of topics related to feature extraction in SBIR, including traditional handcrafted feature-based methods, deep learning-based approaches, feature selection methods, and feature encoding methods. We also identified several challenges and limitations of the current approaches and potential research directions for future work.

3.3 Literature Review

The first paper we reviewed [8], proposes a feature extraction method based on a combination of Hu moments and wavelet transform. The authors note that traditional feature extraction methods, such as SIFT and SURF, are not well-suited for sketch-based image retrieval because sketches are typically more complex and have different characteristics than natural images. The proposed method achieves good performance on a benchmark dataset and demonstrates the effectiveness of combining different feature extraction techniques for sketch-based image retrieval.

The second paper we reviewed [9], proposes a deep learning-based approach to hand-drawn sketch recognition. The author notes that traditional handcrafted features, such as SIFT and HOG, are not well-suited for sketch recognition because they do not fully exploit the unique characteristics of sketches. The proposed double-channel convolutional neural network (DC-CNN) leverages both the gray-scale and stroke-channel representations of sketches and achieves state-of-the-art performance on benchmark datasets.

The third paper we reviewed [10], proposes a large-scale dataset for training convolutional neural networks (CNNs) for sketch recognition. The authors note that previous datasets for sketch recognition were limited in size and diversity, which limited the ability to train deep learning-based models effectively. The proposed dataset contains over 3 million sketches and achieves state-of-the-art performance on benchmark datasets. The authors also propose a CNN architecture that achieves good performance on the proposed dataset and demonstrates the effectiveness of deep learning-based approaches for sketch recognition.

All three papers highlight the importance of extracting meaningful features from sketches and using deep learning-based approaches for sketch-based image retrieval and recognition. The first paper proposes a combination of Hu moments and wavelet transform, the second paper proposes a DC-CNN architecture that leverages both the grayscale and stroke-channel representations of sketches, and the third paper proposes a large-scale dataset and a CNN architecture for sketch recognition. These approaches achieve state-of-the-art performance on benchmark datasets and demonstrate the effectiveness of combining different techniques for optimal performance.

3.4 Conclusion

In conclusion, the field of sketch-based image retrieval has seen significant progress in recent years with the development of feature extraction techniques and convolutional neural networks. The paper by Torabi Motlagh Fard et al. [8] proposed a feature extraction technique that combines local binary patterns and histogram of oriented gradients to represent sketches as compact feature vectors for retrieval. They evaluated their technique on two datasets and showed that it outperforms several state-of-the-art methods. The paper by Zhang [9] proposed a double-channel convolutional neural network that can learn both global and local features from sketches. They evaluated their network on two large-scale sketch recognition datasets and showed that it achieves state-of-the-art performance. Finally, the paper by Zhou and Jia proposed a method to train convolutional neural networks for sketch recognition on large-scale datasets. They evaluated their method on a dataset with over 50,000 sketches and showed that it achieves higher accuracy than other methods.

Overall, these papers demonstrate the effectiveness of feature extraction and deep learning techniques in improving the performance of sketch-based image retrieval and recognition. However, there is still much room for improvement in terms of accuracy and scalability, especially in dealing with diverse styles and variations of hand-drawn sketches. Future research may focus on exploring more advanced feature extraction techniques and developing more robust and scalable deep learning models for sketch-based image retrieval and recognition.

Chapter 4

Work and Implementation

4.1 Implementation Plan

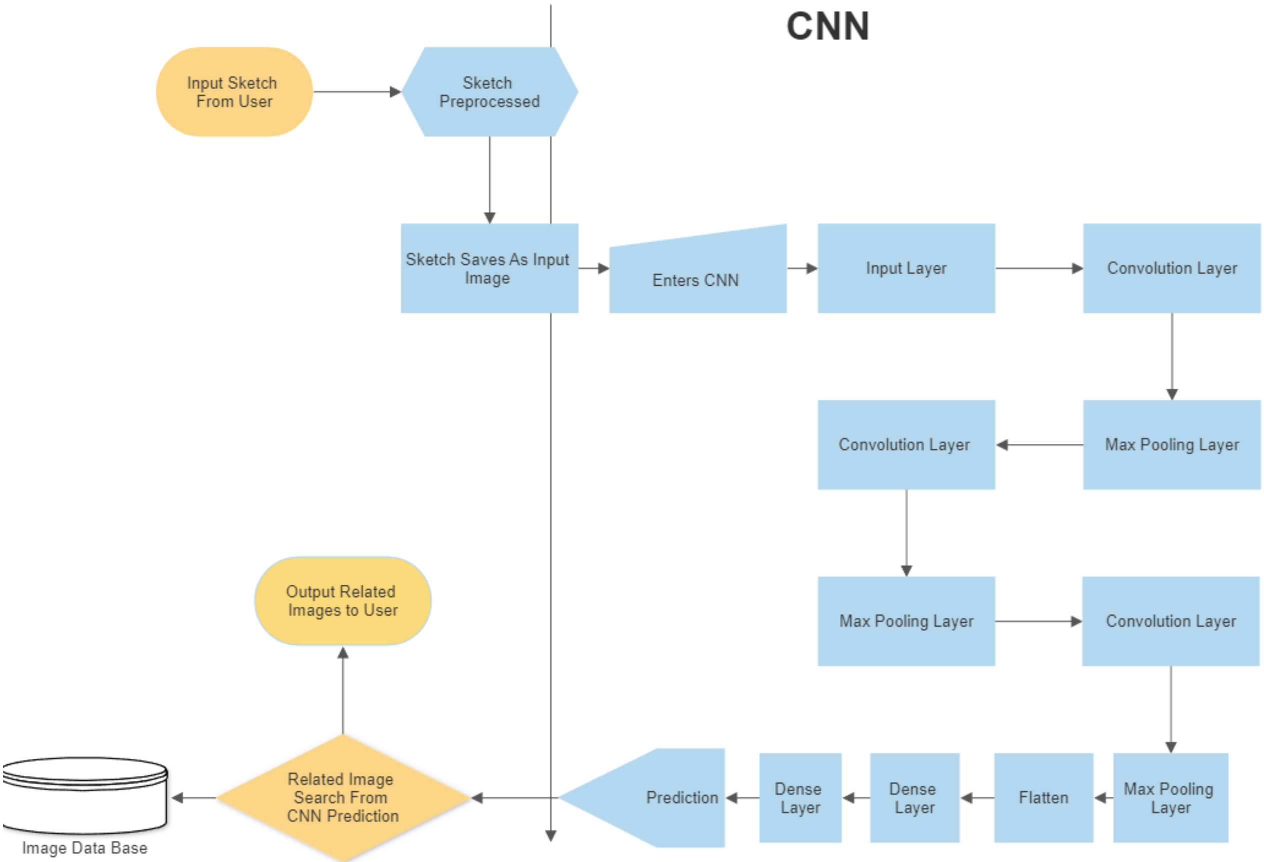

Figure 4.1: Block Diagram for the finished application

4.2 Work Done So Far

The research conducted so far on the feature extraction from sketch-based images (SBIR) thesis has focused on critical steps required to develop an effective CNN model for the task of sketch recognition. Specifically, the first steps of the research involved loading and preprocessing the QuickDraw dataset. The dataset is an extensive collection of more than millions of hand-drawn sketches from over 300 categories, and each sketch is represented as a grayscale image with a dimension of 28x28 pixels.

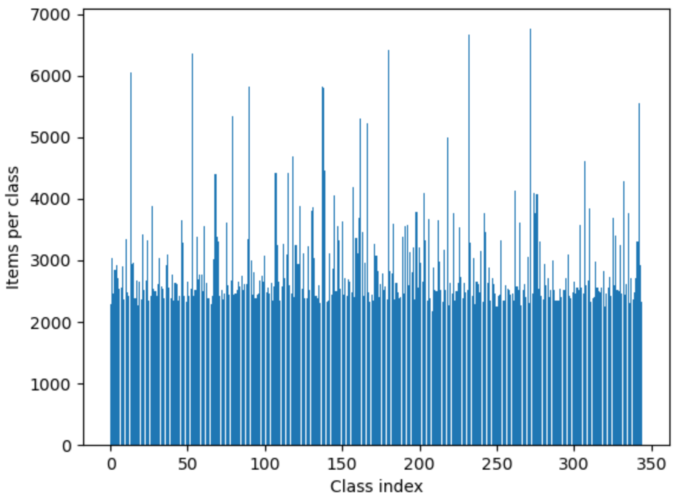

Figure 4.2: Number of Images Per Class

The dataset is divided into training and testing sets, and to prepare it for use in the CNN model, several preprocessing techniques were applied. These techniques included normalizing the pixel values to ensure that they are within a consistent range, one-hot encoding to convert the categorical labels of the images into binary vectors, and label encoding to map each categorical label to a numerical value.

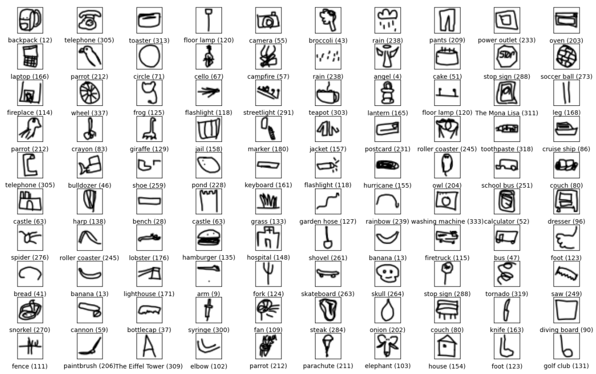

Figure 4.3: Normalized Dataset Samples

Next, the architecture for the CNN model was designed. The model consists of three convolutional layers, each followed by a max-pooling layer and a flatten layer. The convolutional layers are responsible for feature extraction from the input images, and the max-pooling layers help reduce the dimensions of the images. The flatten layer converts the output from the convolutional and max-pooling layers into a one-dimensional array that can be fed into the dense layers. Finally, the two dense layers are designed to process the extracted features and produce the final classification results. The input images to the model are of size 28x28 pixels, which is consistent with the size of the sketches in the QuickDraw dataset. The architecture of the CNN model and preprocessing of the dataset represent a significant milestone towards achieving the research goals of the thesis. However, there is more work to be done, including training the CNN model, implementing it in a web-based application, testing it, and tweaking it to improve its performance.

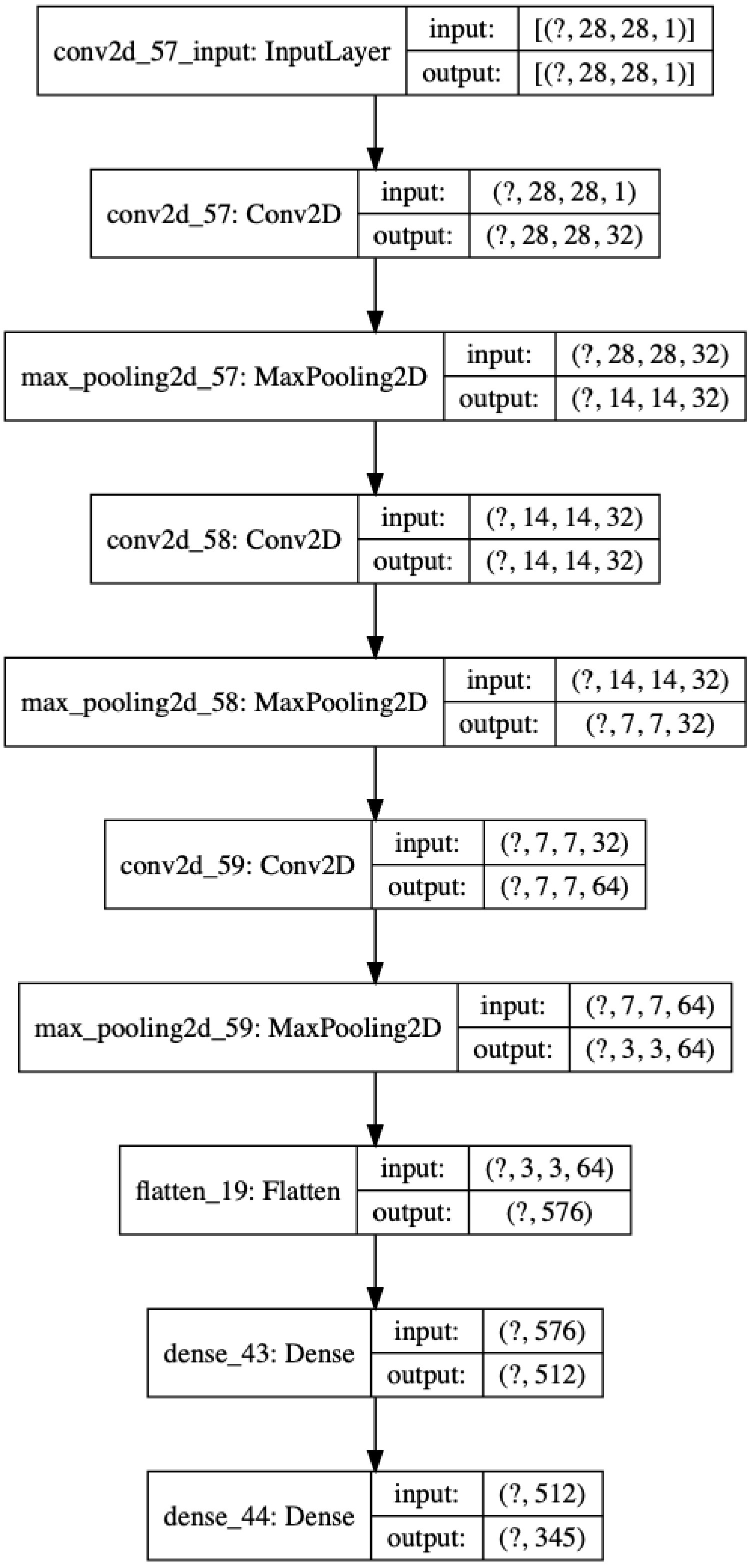

Figure 4.4: CNN Model Architecture

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