

Development of Techniques for Sketched Diagram Recognition

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1. Introduction and Motivation

Hand-drawn diagrams have long been used to express ideas in the early stages of the design process and as a problem solving tool. Computer based diagramming with traditional mouse and keyboard interfaces is highly restrictive. The interaction required is disruptive to thought processes, hampering creativity and good design practice [1, 2]. However the computer offers advantages such as digital storage, transmission, archiving and greater formality of presentation.

With the introduction of pen-based computers, we now have the hardware to model pen and paper interaction. With algorithms to understand the sketches, computational support can offer automatic translation between sketch and formal diagram and an executable sketch model. A number of diagramming sketch tools have been developed however they are yet to achieve general acceptance. One of the outstanding challenges is far more accurate recognition.

Many recognition techniques have been proposed. Regardless of the approach used, there is a reliance on ink features and algorithms to combine these features. Surprisingly, given that ink features are so fundamental to recognition, there is little evidence of the use of formal methods to identify significant features; most reports suggest a reliance on ad-hoc heuristics and empirical trial and error. Furthermore, while various algorithms have been tried, there are no studies scientifically comparing different algorithms.

The focus of my research is to develop general diagram recognition techniques based on quantitative experiments using machine learning to determine the most significant ink features and effective algorithms for use throughout the recognition process. This should improve on existing recognition success rates.

2. Methodology

There are three main parts to this research, data collection, a feature search and formal analysis.

The data collection stage requires a large set of hand-drawn diagrams to be gathered. These will aid analysis and evaluation of recognition techniques. Currently there are no data repositories of hand-drawn diagrams available for public use, therefore this will not only benefit this project but will be invaluable to the sketch recognition research community as a whole. This data must be representative of common diagram components and be collected from a large number of people working in a natural manner (i.e. not copied) in order to limit any statistical bias.

First we must develop a tool to support the management and analysis of a data repository. More specifically this tool should assist in:

- collecting sketched diagrams from people
- efficient labeling of diagrams for analysis purposes using automatic and manual labeling.
- automatic generation of datasets from the diagrams for analysis based on our ink feature set [3]
- automated evaluation of recognition techniques.

There is no known existing tool that is able to perform all these tasks.

A commonality observed between current sketch recognition techniques is that they measure various ink features of a sketch to aid recognition [4-7]. However what is lacking is a definitive set of the most significant features that can be used to provide accurate recognition at all stages of the process.

Stage two of our research is to compile a library of all possible features for further analysis. The feature set compiled in my previous work [3] will be extended to include newly found features, features from other work in recognition and features available from recent hardware advances (e.g. pen tilt). Building program code libraries for feature calculation is essential to facilitate the exploration of various feature combinations.

Once features have been identified, sketches of various diagrams must be collected so that data for each feature can be extracted from these sketches to add to a dataset. This dataset must then be statistically analysed to identify which features are significant to

each stage of recognition. These features will be implemented and evaluated to determine the accuracy of recognition using these features.

Various algorithms have been employed by past recognition engines to combine and select the appropriate features of a sketch [4, 7, 8] for each stage of recognition. However a comparison of these techniques has not been carried out and therefore we do not know which algorithms are most appropriate at each stage of recognition.

Therefore the final stage of our research is to analyse and evaluate possible classification techniques including machine learning and statistical methods. These techniques will be applied to the dataset collected to find appropriate ink features for various stages of recognition.

Once the feature sets are identified different algorithmic approaches to applying these features will be explored. The significant feature sets will be implemented in various algorithms. Finally an overall evaluation will be carried out to determine the combination of features and algorithms that should be used at each stage to provide the most robust and flexible recognition engine as a whole.

3. Preliminary Results

Our research is currently in the data collection stage. We have developed a prototype for the data collection and management tool which supports data collection, labeling and automatic generation of datasets [9].

A usability study was used to test how intuitive and efficient our tool is to use, in particular the data collection and labeling interfaces. Preliminary evaluation results indicate the tool provides a good environment for capturing and labeling ink data for further analysis. It significantly reduces the time and effort involved in performing such tasks.

4. Discussion

The data collection tool developed provides a framework for the processes involved in collecting and managing ink data. It allows us to efficiently capture and label large amounts of data and automatically generate datasets which is essential for our analysis.

Eventually this framework could be used for building recognisers automatically. In addition to its current functionality this would involve building a library of common recognition and feature selection algorithms and an automated evaluator for the recogniser.

The tool could use the feature selection algorithms to pick the features significant to the recognition problem. These features could then be fed into various recognition algorithms to produce a collection of recognisers. An automated evaluator could then rank each recogniser by determining how accurate their classification is on a pre-classified dataset of sketches collected using our data collection tool.

5. Conclusion

Recognition enables us to turn ordinary sketches into formal diagrams and executable models. However the accuracy of recognition techniques must be improved before we can gain any real value. We believe a formal analysis of features and algorithms will help us to construct more robust and flexible recognition engines for hand drawn diagrams.

6. References

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