Towards sketch-based user interface: domain-independent online sketch recognition system

by

Abdelrahman Hassan Ali Fahmy Abdalla

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE
in
COMPUTER ENGINEERING

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Under the Supervision of

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Summary:

With the recent advances in tablet devices industry, sketch recognition has become a potential replacement for existing systems' traditional user interfaces. Structured diagrams (flow charts, Markov chains, module dependency diagrams, state diagrams, block diagrams, UML, graphs, etc.) are very common in many science fields. Usually, such diagrams are created using structured graphics editors like Microsoft Visio. Structured graphics editors are extremely powerful and expressive, but they can be cumbersome to use. This thesis presents a domain-independent sketch recognition system that converts user's sketch into structured shapes in usable electronic format with minimal effort. It supports a wide set of primitives shapes that are common between many structured diagrams. It will allow users to sketch block diagrams, flow charts, etc., using their tablet devices in a very user-friendly and constraints-free manner.

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Contents

List of Tables

List of Figures

List of Algorithms

List of Abbreviations

A	Area
API	Application Programming Interface
CGAL	Computational Geometry Algorithms Library
ch	Convex Hull
DPSO	Discrete Particle Swarm Algorithm
er	Enclosing Rectangle
H	Height
HMM	Hidden Markov Models
K-NN	K-Nearest Neighbors
lq	Largest Quadrilateral
lt	Largest Triangle
MMD	Minimum Mean Distance
NN	Neural Networks
P	Perimeter
PSO	Particle Swarm Optimization Algorithm
RF	Random Forest
SVG	Scalable Vector Graphics
SVM	Support Vector Machine
UML	Unified Modeling Language
W	Weight

Abstract

With the recent advances in tablet devices industry, sketch recognition has become a potential replacement for existing systems' traditional user interfaces. Structured diagrams (flow charts, Markov chains, module dependency diagrams, state diagrams, block diagrams, UML, graphs, etc.) are very common in many science fields. Usually, such diagrams are created using structured graphics editors like Microsoft Visio. Structured graphics editors are extremely powerful and expressive, but they can be cumbersome to use. This thesis presents a domain-independent sketch recognition system that converts user's sketch into structured shapes in usable electronic format with minimal effort. We have presented a robust grouping technique which is based on spatial distance between strokes. We have also introduced the concept of classification preprocessing which is proved to minimize classifiers confusion by doing a precategorization to the shapes. We have compared the accuracies of three classifiers; Support vector machines (SVMs), Random Forest (RF), and K- Nearest neighbor (K-NN). We have also compared the proposed system to benchmark low-level recognizers, and the proposed system proved very competitive accuracy. The proposed system supports a wide set of primitives shapes that are common between many structured diagrams. It will allow users to sketch block diagrams, flow charts, etc., using their tablet devices in a very user-friendly and constraints-free manner. One of the main usages of the proposed system is to be integrated with other domain-dependent sketch recognition systems. The presented system will recognize generic primitives in the early stages and then it will be the task of the domain-dependent system to map these primitives to their corresponding high-level shapes in a specific domain. As an use case, this system will be integrated with a system presented in [48], to test it as a part of domain-dependent sketch recognition system with two applications: GUI design and circuits/electronics diagrams sketching applications.

Chapter 1

Introduction

Sketching is considered as one of the most intuitive languages for expressing human thoughts. One simple sketch can express what thousands of words can. We can use a sketch to draw a scene, show a flow, put a design, etc. Sketches are widely used in many fields of science as a unified language for explaining theories and designs. Thousands of examples for sketching usage can be mentioned. Chemists sketch chemical reaction diagrams and engineers sketch block diagrams, flow charts, class diagrams, circuits design, GUI design, etc. These diagrams are considered as a unified language to explain engineering designs. The majority of engineers prefer to use paper and pencil to draw the diagrams rather than computer software. Meanwhile, it would be more conducive to save these designs in electronic format as it will be much easier to edit and share.

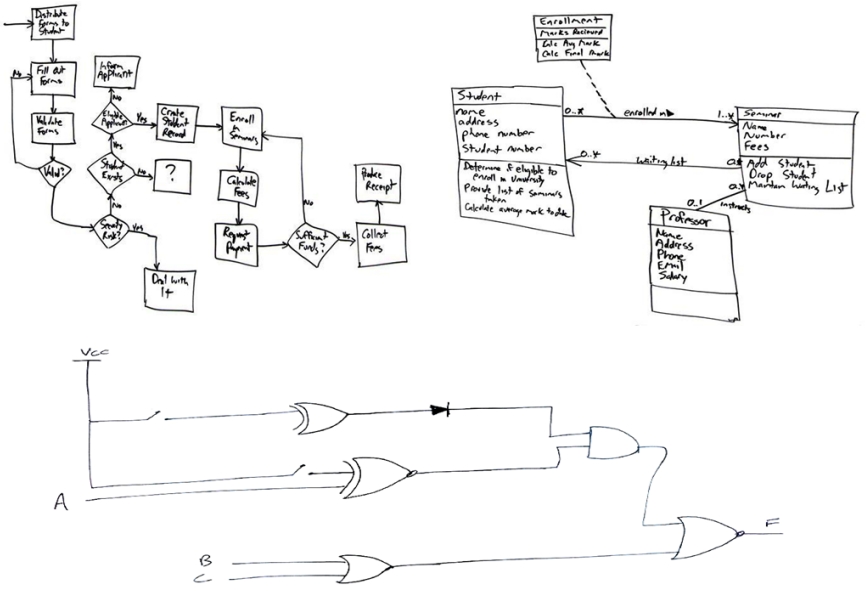

Figure 1.1: Examples of sketch usage

With the rise of tablet devices usage, developing a system that can convert hand-drawn sketches into structured (electronic) format became highly required. It will facilitate sketch creation and modification using Computer Aided Design (CAD) tools. The existing tools mainly use drag and drop feature for diagrams creation. The user constructs the diagram by incrementally selecting from the list of supported shapes. Sketching will provide a more intuitive replacement for this process. In this work, we propose an online