Applying Online Sketch Recognition Algorithms to a Scanned-In Sketch

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ABSTRACT
The goal of our research is to combine the power of stroke-based sketch recognition with the flexibility and ease of use of a piece of paper. In this paper we will present preliminary results of our algorithm integrated with an online sketch recognition system built with LADDER. We have also presented a comparison of our paper based interface with tablet based sketching interface.

ACM Classification: H5.2 [Information interfaces and presentation]: User Interfaces. - Graphical user interfaces.


Keywords: Scanning, Sketch, Image, Sketch Recognition.

INTRODUCTION
As per [6], designers require a computerized tool that can help them to sketch their ideas quickly. As such, tablet-based sketch recognition systems have gained considerable popularity in recent times. However, it cannot be denied that although tablets provide a more sophisticated sketching platform capable of automated understanding and intelligent interaction [2], they cannot match the naturalness, flexibility, easiness and economy that a piece of paper provides [3]. The aim of the presented work is to provide the user with the advantages of a stroke-based sketch recognition system [1, 2, 4] combined with the flexibility and ease of sketching on a piece of paper.

IMPLEMENTATION
Our previous paper [5] described the algorithm for translating a scanned-in bitmap image to online stroke data. In this paper we describe the integration and initial evaluation of our stroke-tracing algorithm with online sketch recognition algorithms built from LADDER [2]. LADDER uses some timing information in its low-level processing [5], so it was unclear if the current online algorithms would continue work with our artificially generated timestamps and if recognition of paper-input sketches using our algorithm would be as successful as tablet-input data.

USER STUDY
Figure 1 shows hand-drawn scanned-in images and their recognized counterpart. In order to verify our claim that 1) scanned-in images could be used in our online sketch recognition algorithms, and 2) that certain features of our paper-based sketching interface would be more preferred than tablet based interface, we conducted a user study involving four subjects. Each of the subjects was asked to draw a diagram on a paper and then on a tablet with a mouse and with a pen. At the end of the user study, participants were asked to complete a survey in which they had to report their responses on a scale of 1 (best) to 3 (worst). The preliminary results of the algorithm integrated with LADDER are shown in Figure 1 and Table 2, with results of the user study shown in Table 1.

The study demonstrated that all of the users agreed with our perception about the advantages of a paper-based interface compared to the tablet-based interface. Users agreed with us that paper-based input provides more naturalness and freedom than tablet-based interfaces and hence can be preferred. One of the subjects commented that that even though tablet-based interfaces are interesting and sophisticated, they lack the frictional feedback that paper provides while sketching. Some users with extensive experience of using tablet-based interfaces argued that even though paper based sketching is more natural, tablet based sketching provides them with the ability to store the information digitally which they can either share through emails or store in storage devices. Some users also complained that since users have much more practice and are accustomed to working with paper, that it is not a fair comparison. How-
ever, they did agree that paper based sketching is much more universal and easily adaptable than tablet based systems.

Figure 1: The left side shows the scanned in image and the right side shows the scanned image recognized in LADDER [3].

<table>
<thead>
<tr>
<th>Question</th>
<th>Tablet</th>
<th>Paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which of the two interfaces?</td>
<td>Pen</td>
<td>Mousse</td>
</tr>
<tr>
<td>Has a lower learning curve?</td>
<td>2(4)</td>
<td>3(4)</td>
</tr>
<tr>
<td>Is easier to use?</td>
<td>2(4)</td>
<td>3(4)</td>
</tr>
<tr>
<td>Has better feedback?</td>
<td>2(4)</td>
<td>3(3)</td>
</tr>
<tr>
<td>Can be easily used in large setting?</td>
<td>2(4)</td>
<td>3(3)</td>
</tr>
<tr>
<td>Provides the freedom of sketching?</td>
<td>2(4)</td>
<td>3(4)</td>
</tr>
</tbody>
</table>

Table 1: The number in the bracket shows how many subjects gave the score on Left.

In order to analyze the accuracy of the application of online sketch recognition algorithms on data obtained from our stroke extraction algorithm, we conducted another user study involving three subjects. Each one of them was asked to draw a music sheet diagram and a Tic-Tac-Toe game. Accuracy of the sketch was measured as

\[
\text{Number of sketch components recognized} = \frac{\text{Total number of sketch components in sketch}}{\text{Number of sketch components in sketch}}
\]

A sketch component is the constituent of a sketch representing a complete shape. For example, a music note is a single sketch component.

It was observed that music notes in the sheet music domain were not recognized correctly. This was because the sketch recognition system was unable to effectively fragment the stroke into an oval and a shaft, which comprises a music note. This can be attributed to the observation that there is no effective corner available in the music note that can be used for segmentation of stroke into two constituents (oval and a shaft).

Figure 2: The left shows the original strokes as seen in LADDER after applying the stroke-tracing algorithm on two scanned-in sketches. The right shows the version after the low-level recognizer was applied.

In order to compare our results with the online system, we conducted another user study in which the same users who had participated in the first user study participated. They were shown their sketches, which they had created on paper and told to sketch the same on a tablet. However, they were instructed to sketch music notes as a single stroke. (Segmenting a circle from a line in a complex stroke is a difficult research problem.) Table 2 shows the comparison of accuracy results obtained:

<table>
<thead>
<tr>
<th>Sketch</th>
<th>Tablet</th>
<th>Pen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Music-1</td>
<td>0.7</td>
<td>0.8</td>
</tr>
<tr>
<td>Music-2</td>
<td>0.667</td>
<td>0.778</td>
</tr>
<tr>
<td>Music-3</td>
<td>0.778</td>
<td>0.667</td>
</tr>
<tr>
<td>TicTacToe-1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>TicTacToe-2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>TicTacToe-3</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 2: Accuracy Table Tablet Vs. Paper

It can be seen that we obtained nearly similar results with the online system as we obtained using paper based interface. Also it is worth mentioning that the, artificially gener-
ated time stamps, that we created for using the online sketch recognition system (LADDER) seemed to be effective for recognition.

FUTURE WORK
For future work we wish to do further examination of the hand-drawn strokes to be able to ascertain the start and end of a stroke only from paper-based artifacts. Additionally, we would like to be able to automatically determine the pressure of a pen from the line thickness on a page.

CONCLUSION
This paper describes a user study that compares the recognition results from a tablet input system to a paper-input system using our stroke extraction algorithm when applied to the high level LADDER recognition algorithm. Our preliminary user study demonstrated that our paper-input interface provides similar accuracy to the tablet-input interface.

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REFERENCES