

# Guided Gesture Support in the Paper PDA

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## ABSTRACT

Ordinary paper offers properties of readability, fluidity, flexibility, cost, and portability that current electronic devices are often hard pressed to match. In fact, a lofty goal for many interactive systems is to be “as easy to use as pencil and paper”. However, the static nature of paper does not support a number of capabilities, such as search and hyperlinking that an electronic device can provide. The *Paper PDA* project explores ways in which hybrid paper electronic interfaces can bring some of the capabilities of the electronic medium to interactions occurring on real paper. Key to this effort is the invention of on-paper interaction techniques which retain the flexibility and fluidity of normal pen and paper, but which are structured enough to allow robust interpretation and processing in the digital world. This paper considers the design of a class of simple printed templates that allow users to make common marks in a fluid fashion, and allows additional gestures to be invented by the user to meet their needs, but at the same time encourages marks that are quite easy to recognize.

## Keywords

Hybrid paper electronic interfaces, interaction on paper, augmented reality, interaction techniques, recognition.

## INTRODUCTION

The Paper PDA project [1] seeks to allow marks made on real paper with an ordinary pen to be used to implement the functions of a typical palm sized electronic organizer. The Paper PDA system prints pages containing information such as calendar entries, to-do items, and contacts lists. To make processing these pages easier, elements such as registration marks and machine recoverable identifiers, as well as printed affordances for interaction or *paper widgets* (such as the one discussed here, and motivated by the early work of [2]) are included. Periodically, the user scans in their Paper PDA pages, and the system extracts and processes information it finds there – performing specialized processing in areas it knows contains paper widgets. The system then acts on this information to carry out actions in the computational world, such as updates to the user’s data, or the sending of appropriate messages. Finally, a new copy of the Paper PDA contents is formatted and printed. This cycle of printing, scanning, processing, and reprinting of the Paper PDA provides the logical equivalent of “synchronizing” an electronic PDA. As such, it provides a general platform in which marks on ordinary

paper by a normal pen can act in the electronic world.

A central question in this domain is how to create on-paper interaction techniques that remain fluid, but which are structured enough to let a system very easily interpret and act on them. This is particularly important for the paper PDA because it operates *off-line*, making recognition harder (due to the lack of temporal stroke information), and the consequences of errors greater (due to very long action-response cycles times). In order to improve recognition rates, but maintain highly fluid interaction, we are developing a variety of interaction techniques of this form – what we call *semi-structured*, indicating that they are not fully free form, but are also not rigidly structured. (Early in the project, we also considered physical plastic templates to accomplish this, but considered them too rigid and cumbersome for fluid use).



Figure 1. Template and common gestures (enlarged)

This paper considers a class of printed templates for making gestures in a semi-structured fashion. These templates provide a guide for making marks that can form a wide range of gestures. In particular, they provide a set of wide “tracks” indicating the approximate positions for user strokes. Gestures supported include those we know a priori are useful and likely (as illustrated in Figure 1), as well as gestures that users invent to meet their own particular needs. For example, the template in Figure 1 supports at least 1024 distinct gestures formed by the presence or absence of a mark in each of 10 possible segments. The tracks provided by the template are suggestive of where a mark may be made, but the user need not stay within the lines. Nonetheless, the template provides an affordance that encourages more uniform markings, and provides a grounding position, size, and orientation that make recognition of them much easier.

## TEMPLATE DEVELOPMENT

Our initial conception of the idea of a marking template resembled the early design shown here.



This template form offers an advantage of generality – it supports a fairly wide range of possible gesture forms and represents a good alternative when a large or unknown gesture set needs to be supported. (We also considered a form of template where users mark *on* the lines instead of between them, however, that form makes the recognition task significantly harder and was consequently abandoned.)

After this early conception, we did some quick informal observations of the use of paper in our office, and in our

own work, to gather some commonly used marks. Early on, we noted that “to-do” lists had a particular need for this sort of semi-structured interaction and adopted support of that task as our design goal. On to-do lists, people tend to place marks next to items to indicate actions to be taken, completion status, or designation of categories. One of the virtues of conventional paper for this task is that users can devise and evolve a system of symbols expressly for their own particular needs. Further, when new needs arise (e.g., the need for a new category), they can simply invent a new symbol and start using it immediately. Since users designate their own symbols and meanings, the resulting learning burden is extremely low. This flexibility and fluidity of paper systems is one key to their popularity and ease of use, and something that is often lost when moving to electronic analogs.

In considering the to-do list task we compared observed marks with the affordances of the template. Among the common marks we observed were check marks, X’s, asterisks, arrows, dashes, and dots, bullets or small circles. However, we noted that check marks (which are clearly very useful for to-do lists), as well as arrows, were not directly supported by the circular template. This led us to consider some alternate shapes as a more targeted instance of the guided gesture concept. By considering an approximate union of the line segments making up common marks (i.e., ✓ → X – \* together forming: ↗↘), we arrived at a design similar to the current shape. After some additional iteration and experimentation (asking people to draw both fixed and invented symbols in the templates), we settled on the design shown in Figure 1. This design is asymmetrical so that it supports a natural angle for both a check mark and a right arrow, and is also still good for an X and a left arrow. This template also supports dots or small bullets in several different locations, two places for an approximate circle, and additional symbols such as a tilde. Finally, this design offers the advantage of a more horizontal aspect ratio that better matches lines of text (e.g., for a given size of accompanying text, a larger template may be used).

<b>Define Gesture:</b>		<b>Confirm:</b>					
<b>Associate with:</b>	<input type="checkbox"/> High	<input type="checkbox"/> Normal	<input type="checkbox"/> Low	<input type="checkbox"/> Finished			
	<input type="checkbox"/> Sort	<input type="checkbox"/> Delete	<input type="checkbox"/> Set Due	<input type="checkbox"/> Delegate			
	<input type="checkbox"/> Category: _____						

**Figure 2. A Gesture Definition Form**

### USER DEFINED GESTURES

To accommodate user defined gestures in an application like a to-do list manager, we can provide a series of special symbol definition forms. As illustrated in Figure 2, these forms would contain several templates for sample gestures along with an action specification area with check boxes for known commands and categories, plus an open-ended “write-in” area for additional categories. The user would define a new gesture to the system by drawing several

examples for it, and then either checking an alternative corresponding to a predefined system concept, or creating a new symbol associated with an (uninterpreted) handwritten label.

### RECOGNITION

A central goal of the guided gesture template is to make recognition of gestures easy (and hence allow very high recognition rates). To test the effectiveness of this, we have deliberately chosen to use a relatively simple recognition scheme. This scheme works by breaking the marking areas of the template into distinct regions and doing simple tests detecting the presence or absence of an appropriate mark in each of these regions. We then recognize each gesture simply by finding the closest matching set of regions in our gesture set, where closeness is measured by the number of region marks that must be added or removed to transform the sample regions into the target regions.

In a test of recognition rates, we collected 400 sample marks over the template – five copies of each of the gestures: ✓ → X – \* made by 16 different users. Each user was given a template sheet with the first template of each column filled in with a symbol. Each was asked to “copy the symbols into the templates below.” No specific instructions regarding speed or accuracy were given. Both “sloppy” marks indicating quick marking, as well as fairly “neat” marks were observed in different users.

We found that two of the gestures were clearly “false starts” not matching the intended gesture and discarded them. Of the remaining 398 gestures, our system correctly recognized all but three of them for a recognition rate of 99.25%.

### CONCLUSION

This paper has described a simple technique for semi-structured interaction on real paper using guided gesture templates. These templates go beyond the fixed form on-paper interactions of previous systems, supporting a range of different expressions by the user, but at the same time help to structure the user’s input so that it can be recognized with very high reliability. This reliability is critical in off-line recognition systems such as the Paper PDA, but might also be quite helpful in a range of other pen-based systems.

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