TACTICS: A TACTILE IMAGE CREATION SYSTEM

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ABSTRACT

Visual information is increasingly important yet methods for its access by blind persons are inadequate. This paper describes and evaluates TACTICS, a system for the automatic visual to tactile translation of digitized images. The results of experiments testing perception of TACTICS-generated tactile images are provided.

BACKGROUND

Access to visual information can widen the avenues of professional and social interactions for blind persons. Yet, while the volume of such graphical information increases, as with the ubiquitous Internet, methods for meaningfully exploring this information are not keeping pace.

Computer text is accessed using speech synthesizers and braille displays and printers. Graphical information, however, is virtually inaccessible, a significant barrier for the blind computer user.

The conversion of visual information to static tactile form can be time consuming, involving the assistance of a trained sighted person [1]. Research in the areas of dynamic tactile displays and multimodal feedback systems is active [2, 5], although technological advancement has been slow.

Investigation in the area of *tactual perception* [3] identifies important factors that can guide the translation of visual information into a meaningful tactile form [6]. These factors include the disparity of resolution between the eye and fingertip, optimal size for a tactile graphic, and how the mind classifies and uses visual information.

This paper describes a unique system for the automatic translation of visual images into tactile graphics, or *tactics*. The TACTile Image Creation System (TACTICS) combines lessons learned from the areas of human perception and tactile graphic production with image processing techniques. The results of four experiments designed to test this system are reported and discussed.

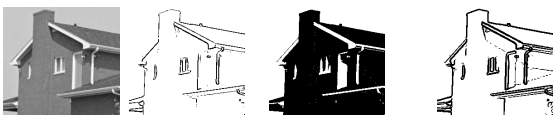
RESEARCH QUESTION

Can visual images be automatically translated into tactile images such that a blind person can make meaningful use of the result?

METHOD

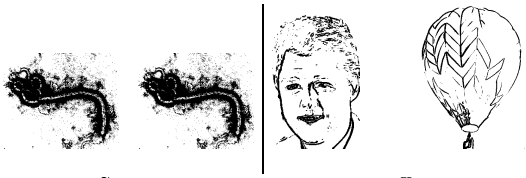
The process of converting a visual image into a tactile one using TACTICS requires three steps: (1) *acquisition*, where the original image to be viewed is obtained, in this case from image databases on the Internet and elsewhere, (2) *simplification* using a number of image processing techniques [4] to reduce the level of detail and complexity of the original (Figure 1), and (3) *rendering* in tactile form, during which the simplified image is output on microcapsule paper.

Four experiments were performed to



(a) None (b) Sobel (c) K-means (d) Aggregate

Figure 1: TACTICS image processing. Aggregate process is blurring, edge detection, segmentation and median filtering.



Same Different

Figure 2: Discrimination experiment examples.

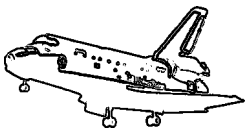


Figure 3: Identification experiment example.
Which best describes this image?
(a) shuttle (b) shark (c) bus (d) Florida

measure how TACTICS processing affects four types of tactile image perception. Simple- and timed-discrimination tasks tested the effect of four forms of processing on the ability of a subject to discriminate between randomly matched pairs of tactile images, with and without a time deadline, determining whether each pair was the same or different (Figure 2).

An identification experiment measured the effects of the same processing on a subject's ability to identify the content of a series of tactile images, categorizing each into one of four possibilities (Figure 3).

Comprehension was measured using a series of tactile images, each with a brief textual description and questions testing the ability of subjects to explore them, then understand features, locate features, and reason about image content (Figure 4).

Ten subjects were used, ranging in age from 22 to 60 and with little or no previous experience with tactile images. Seven subjects were male and three were female. Three were blind and seven were sighted and blindfolded. Forty trials of the simple- and timed-discrimination and identification experiments, and ten of the comprehension experiment were performed for each subject. Empirical and observational data was collected during the experiments.

Figure 4: Comprehension experiment example.
Description: This is a personal computer.
Understanding: This is a:
(a) desktop computer (b) notebook computer
Location: Locate the keyboard.
(a) (successful) (b) (unsuccessful)
Reasoning: Is the computer on or off?
(a) computer is on (b) computer is off

RESULTS

Tables 1, 2, and 3 contain the results of the simple- and timed-discrimination, identification, and comprehension experiments. These results are reported in exhaustive detail in [6].

DISCUSSION

Subjects performed well on all tasks, indicating that the image processing techniques used in TACTICS are beneficial to discrimination, identification and comprehension of tactile images.

Discrimination for all subject groupings improved with use of the more involved aggregate processing compared with the other forms tested, indicating that simplification improves discrimination. While overall performance degraded slightly with the added pressure of the timed-discrimination task, blind subjects tended to perform somewhat better, perhaps a result of a greater inherent reliance upon the sense of touch for perception in general.

The identification experiment proved the most difficult for subjects, with the best results again for the aggregate process. Sighted subjects performed 15% better

Table 1: Correct response rates: simple- and timed-discrimination experiments. (Chance rate is 50%.)

	Simple				**Timed**			
Processing	*Blind*	*Sighted*	*Overall*	*p*	*Blind*	*Sighted*	*Overall*	*p*
None	53%	53%	53%	2.9e-1	43%	60%	55%	6.5e-1
K-Means	83%	82%	82%	6.0e-1	87%	73%	77%	4.9e-1
Sobel	63%	84%	78%	6.4e-2	73%	73%	73%	1.9e-1
Aggregate	90%	96%	94%	7.5e-1	93%	84%	87%	7.5e-1

Table 2: Correct response rates: identification experiment. (Chance rate is 25%.)

Processing	*Blind*	*Sighted*	*Overall*	*p*
None	10%	6%	7%	4.8e-1
K-Means	57%	54%	55%	7.9e-1
Sobel	43%	47%	46%	7.2e-1
Aggregate	77%	89%	85%	1.1e-1

Table 3: Correct response rates: comprehension experiment. (Chance rate is 50%.)

Processing	*Blind*	*Sighted*	*Overall*	*p*
Understanding	90%	80%	83%	6.5e-8
Location	69%	89%	83%	3.5e-9
Reasoning	79%	79%	79%	4.5e-14
Overall	80%	83%	82%	1.4e-15

than blind subjects, possibly due to the visual nature of the image content.

Subjects performed quite well on the comprehension experiment, suggesting that even brief textual descriptions are beneficial. Blind subjects performed better with content understanding tasks, perhaps due to a more practiced reliance on the sense of touch.

Observations made during the experiments include that both blind and sighted subjects (1) developed identical strategies for tactile image exploration, (2) provided unsolicited and accurate remarks about images indicating deeper comprehension than was measured, and (3) had corresponding ease or difficulty with many of the same tactile images.

The significance of these results is that they demonstrate that reasonable and comprehensible access to visual information *can* be provided to blind persons, and be done so without the intervention of a sighted facilitator. Thus, a blind computer user might one day "surf the web," browse a CD-ROM collection of computerized images, or navigate a GUI, unaided and with a better degree of comprehension than is currently possible.

We plan to investigate TACTICS as a visual pre-processing front-end for dynamic tactile displays, and to extend its development to a stand-alone user application.

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