Protecting Against Screenshots: An Image Processing Approach

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As enterprises exploit electronic devices to share documents/images, there is an increasing need from business and social domains for technologies which protect documents/images (especially those whose contents are sensitive e.g. business plans and private chat messages) from being illegally copied by screenshots and thereby comprising the privacy of the data. Traditional methods take a system architectural approach to protect against screenshots. One of the common approaches is to use application specific plugins to poll for screenshot events e.g. pressing of the print-screen key. For example, SnapChat, a popular mobile application that was recently developed to support secure exchange of messages/images, automatically notifies the sender if a screenshot event is detected at the recipient's mobile device.

We depart from this framework, and instead exploit image processing techniques, coupled with human biological vision, to limit meaningful contents of data presented on a display from being captured by screenshots. Our method takes visual data of the display as input, distorts the visual data, and then presents the distorted data back to the viewer. The novelty of our approach lies in the distortion method, which distorts visual contents of static data (e.g. text) shown on a screen with a focus that humans can automatically recover the distorted contents into its meaningful visual form in real-time.

The underlying idea of our method lies in the findings that humans process visual data as a series of visual snapshots [1]. Recent psychological studies [2, 3, 4] have demonstrated that there is a brief persistence of visual information in a viewer's short term memory. This carryover of visual information from recent fixations helps a viewer constructs a coherent representation of the current scene over several fixations. In this aspect, what we see at an instance in time is a subtle blend of the preceding and present fixations. We exploit this persistence of visual information in the short term memory to develop our visual contents distortion algorithm, where we model the smooth blending of visual information from previous and present fixations by an additive process so that the distorted visual data can be directly and mentally recovered by the viewer into a meaningful form. Fig. 1 outlines the proposed method. Given visual data of the screen, we first compute a set of intermediate distorting planes. Values within these planes are randomly generated and support lossless recovery of the distorted data. We use these planes to generate a set of final distorting planes, and distort the visual data with these planes. The distorted data are then presented in quick succession to the viewer, where meaningful contents of the screen are automatically and mentally recovered by the viewer. Given that visual data shown on the display is distorted, screenshots yield little meaningful visual information. We believe the proposed method increases the difficulty of stealing meaningful data with screenshots, and introduces a novel paradigm to limit useful visual information from being captured by screenshots.

To distort the visual contents with a focus that humans can automatically recover the distorted contents into its meaningful visual form, the distortion algorithm should satisfy the following requirement:

- The distorting value should be random computed such that the original visual content cannot be recovered from screenshot of distorted pixel
- The distorted pixel should be able to be displayed on the screen
- The visual content should be reconstructed losslessly when distorted images are combined.

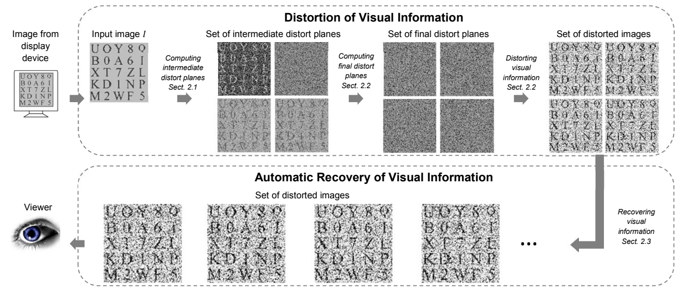

Figure 1: System overview of our method to limit meaningful data from being captured by screenshots. Illustrations shown are obtained with $n = 4$ distort planes. In practice, we use around $n = 22$ distort planes, which increases the method's ability to protect against screenshots.

We term a static display of the screen as image I, and denote the intensity at (x, y) coordinate of the screen as $I(x, y)$. Let α and β be respectively the minimum and maximum intensity that can be displayed on the screen. Our goal is to seek n distorting planes $D_1, \dots, D_n$ (each with the same dimension as I) that can be arithmetically added to I to hide its contents. The set $\{D_j\}$ should satisfy the following equations,

$$D_j(x,y) = \text{random number} \quad (1)$$

$$\alpha \leq D_j(x,y) + I(x,y) \leq \beta \quad (2)$$

$$\sum_{j=1}^{n} [D_j(x,y) + I(x,y)] = \sum^{n} I(x,y) \quad (3)$$

Eq. (1) specifies our requirement that each distorting value $D_j(x,y)$ is randomly computed. Eq. (2) expresses our requirement that a distorted pixel can be displayed on the screen. Eq. (3) ensures contents of an image can be reconstructed losslessly when distorted images are combined. In this paper, an iterative framework is developed to generate the desired distorting planes.

A detailed evaluation of the proposed method to protect contents of documents from being copied by screenshots has been conducted. In the experiments, we create 1000 test images each of size 100×100 and contains 25 random characters (alphabets and numbers only) that are arranged in a 5×5 grid. User study demonstrates the feasibility of our method to allow viewers to readily interpret visual contents of a display, while limiting meaningful contents from being captured by screenshots. Additionally, we also demonstrate how the proposed method can be readily extended to protect meaningful visual data of movies from being captured by screenshots. To our knowledge, this is the first approach which exploits image processing techniques to limit useful visual information from being captured by screenshots.

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This is an extended abstract. The full paper is available at the Computer Vision Foundation webpage.