

# NoteLink: capture your handwritten note by taking a shot (progress report)

## ABSTRACT

The ability to digitize handwriting annotation from mobile device would allow people to enjoy the ease of physical document reading with the convenience of digital document organization. However, currently there is a lack of support for people to do it conveniently with mobile devices. To address this problem, we created NoteLink, a system allows user to take one camera shot and instantly get the digital document with handwritten annotation. NoteLink collect a library of users recent printed document on desktop. A program warp the image of document taken and match it against the library, to find the handwriting part and automatically created an annotated copy of the document. NoteLink utilize sensors on mobile phone and recent printed document history to provide a high accuracy and easy to use capture and access system for handwriting annotation.

## INTRODUCTION

Handwriting annotation capture has always been an important technical problem as it can enable many useful use scenario[1, 7]. However, current solutions is either not convenient[6] or require extra device[8]. Those solutions either need a specific environment with not portable equipments, or need specialized device like a pen or a notebook. They introduce extra burden to the user and make it hard for their plan to be adopted in real life.

Our goal is to empower users the ability to quickly and easily capture their handwriting annotation and review them on the original document. To achieve this, we have developed NoteLink, a software system that transform a mobile phone to a portable scanner and extractor for handwritten content. Inspired by how people already use their smartphone, NoteLink allow user to take a picture of their document and automatically extract the handwriting and their location according to the original document. Our app automatically record all the document user printed on their desktop and phone. With the help with accelerometer embedded in the phone, our app warp the image taken to a near upright snapshot of the annotated document, search for and compare with the original document and extract the annotation stroke in the difference (see Figure 1).

Prior research has explored several solutions for user the capture handwriting annotation; NoteLink expands on their work in two important ways.

First, NoteLink provides a truly mobile-based solution. Unlike other approaches, which requires user to setup a specific environment[6], use a special handwriting tool[8]. NoteLink allows user to use their own tools to compose their annotations. This makes our system very appealing to most people who have their preference on handwriting devices. Additionally, with prior work has shown how annotation can be

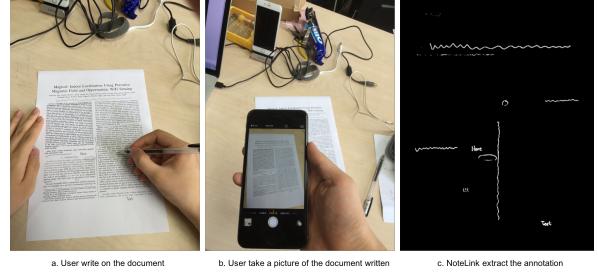


Figure 1. User workflow to record handwriting annotation using NoteLink

captured by have device recording while making annotations, our system enable user to capture their handwriting off-site, which allow our system to be more flexible to suit more scenarios.

Second, NoteLink shows innovative use of sensor data and context information to enhance interaction experience and improve accuracy. In contrast to prior works where most of them requires the camera to vertical to the writing plane[6], which is hard to be achieved by regular use without help of other equipment. This system utilize the motion sensors retrieved from the time user take the document picture to deduct relative angle between the paper and the camera to reduce distortion. This work also utilize the document the user has printed as a context to address the issue that it is hard to classify user annotation from printed document[4].

## SYSTEM DESIGN

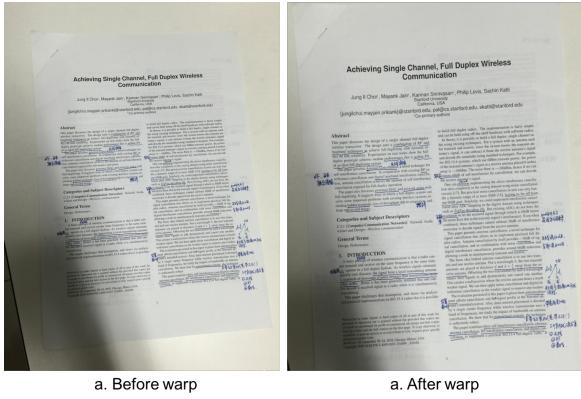
NoteLink is a mobile application running on users smart phone. When users take a photo of the annotated paper, the photo and the angle relative to ground is recorded. These data then go through a workflow: 1) Warp the image upright, 2) Find the original document, 3) Refine the warp by different section, 4) Extract difference and generate annotated document. At the end, a annotated digital document is generated.

### Warp the image up right

After user took the image, the app record the camera heading from sensor and the full-resolution photo from the image sensor. Perspective distortion introduced by camera shot can be classified as rotate, scale and tilt, this step tries to overcome the tilt distortion to improve the accuracy of the later step[5]. NoteLink make a reasonable assumption that the paper is placed on a table that is parallel to ground, so that the app first warp the picture roughly according to the camera angle to counteract the effect of tilt distortion. (see Figure 2)

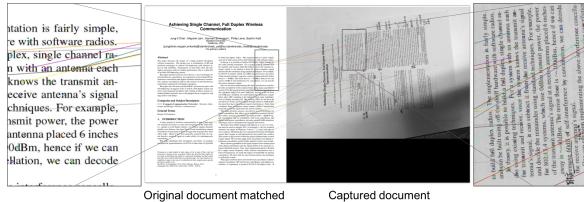
### Find the original document

NoteLink have the context information of a set of document that the user has recently printed. We blur and threshold the



**Figure 2. Comparison of captured photo before and after this process**

document images in advance to extract each word in the document as a point, and hence a set of points for each document is produced. We apply the same procedure to the processed image of the annotated document, which produced another set of points. As the relative locations of the points of the annotated document should resemble the original document in the printed document set, we use a method called as Locally Likely Arrangement Hashing(LLAH) to index and match the original document. (see Figure 3)



**Figure 3. Original document and captured image:** colored circle represent a word point, colored line represent a match from the algorithm; 2 zoomed image in the picture show enlarged detail in the figure.

### Refine the warp by different section

As the original document is found, we can warp the processed image from step 1 to generate a image with all distortion eliminated.

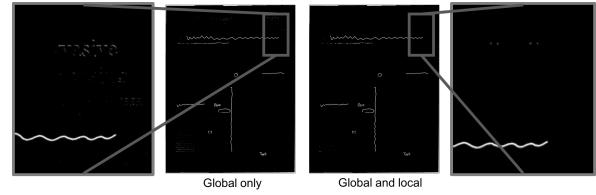
First, we use the points set in the original image and the annotated image to find a warp matrix. NoteLink use RANSAC[2] algorithm to deduce global warp matrix.

In addition to a global wrap matrix, as paper usually have some winkle that distort the image in local area, we divide the image to several parts and generate local warp matrix using the same method to overcome that effect.

Figure 4 shows the comparison between the absolute difference of the original document image comparing to the image warped by only global matrix and image warped by both matrix.

### Extract difference and generate annotated document

NoteLink then use the processed image from step 3 and generate difference between captured image and image produced from original document to extract only the handwriting. To

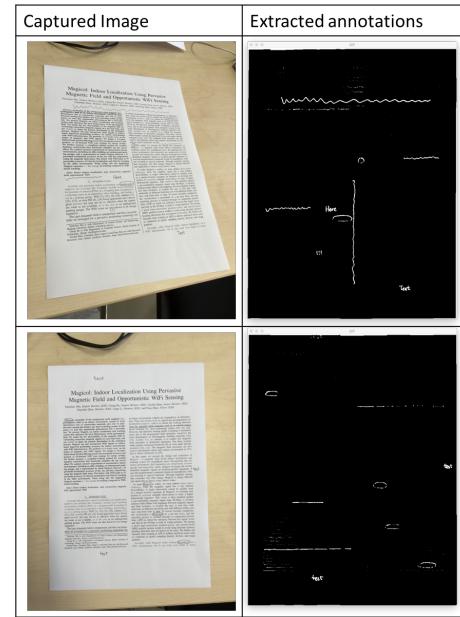


**Figure 4. Original document and captured image:** colored circle represent a word point, colored line represent a match from the algorithm; 2 zoomed image in the picture show enlarged detail in the figure.

further suppress the problem that printer sometimes will print bolder or thinner font causing a border of printed character to be extracted with the handwritten annotation. We segmented the annotated document to different stroke[3] and calculate the proportion of area is also covered by the original image. NoteLink remove all the stroke which have a high proportion area covered by original document image (indicate this is likely one stroke that already present in the original document).

### EVALUATION

No user study has been done at this moment. However, Figure 5 shows a few experiment results.



**Figure 5. Some preliminary result for NoteLink**

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