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Image based low cost method to the OMR process for surveys and research

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ABSTRACT
OMR (Optical Mark Recognition) is the standard technique used to scan a marked paper to detect the presence or absence of the mark in a predetermined position. This technology is widely used in applications like Institutional research, community surveys, consumer surveys, examinations, data compilation, product evaluation etc. The most important use of OMR is the detection of pencil marked bubbles in optical answer sheets used in Multiple Choice Question examinations. Drawbacks with the OMR technique is that, it cannot process thin quality papers and low printing precision answer sheets. This paper analysis a new technique that overcomes the limitation of OMR process. It scans the hard copies of papers which are designed and marked in a specific template and saves that scanned copy in JPEG format, then identifies the marked responses from the JPEG image and stores the result in database. Errors and their solutions which could creep in due to scaling, rotation, translation of the scanned copy are also presented.

General Terms
Pattern Recognition, OMR, Surveys.

Keywords

Optical Mark Recognition, Image Based Technique, Template Matching

1. INTRODUCTION

Optical Mark Recognition (OMR) is a “mark sensing” technology in which data is input via marks made in predefined positions on a form and entering data into a computer system. OMR technique works with a dedicated scanner device that shines a beam of light onto the paper. The contrasting reflectivity at predetermined positions on a page is then utilized to detect the marked areas because they reflect less light than the blank areas of the paper. Some OMR devices use forms which are pre-printed onto 'trans-optic' paper and measure the amount of light which passes through the paper, thus a mark on either side of the paper will reduce the amount of light passing through the paper

Some OMR systems require special paper, special ink and a special input reader [6]. This restricts the types of questions that can be asked and does not allow for much variability when the form is being input. Progress in OMR now allows users to create and print their own forms and use a scanner (preferably with a document feeder) to read the information [6]. The user is able to arrange questions in a format that suits their needs while still being able to easily input the data [6]. OMR systems approach one hundred percent accuracy and only take .005 seconds on average to recognize marks [6]. Users can use squares, circles, ellipses and hexagons for the mark zone. The software can then be set to recognize filled in bubbles, x’s or check marks.

OMR technology can be used when a large volume of data must be collected and processed in a short period of time or Data are to be collected from a large number of sources simultaneously such as in community surveys, consumer surveys, Test, assessments, evaluation, feedback, lotteries, voting etc. Questionnaires mainly comprise the selection of categories or "tick box" answer to multiple choice questions.

Some limitations of the current OMR technology are that it requires an expensive high computational hardware machine (reader)

and a high quality (90-110 gsm) paper (forms) for scanning. Moreover it is not a good solution for small scale companies or organizations as the reader is quite sensitive. The forms should be in perfect condition, if they are crushed or even folded they may be rejected by the Optical Mark Reader.

2. RELATED WORK

The first mark sense scanner was IBM 805 Test Scoring Machine; that read marks by sensing the electrical conductivity of graphite pencil lead using pairs of wire brushes that scanned the page [6].

Chinnasarn et al [1] present a system based on PC-type microcomputer connecting to an image scanner. The system operations can be distinguished into two modes: learning mode and operation mode. In the learning mode, the model corresponding to each type of answer sheet is constructed by extracting all significant horizontal and vertical lines in the blank-sheet image. Then, every possibly cross-line will be located to form rectangular area. In the operation mode, each sheet fed into the system has to be identified by matching the horizontal lines detected with every model. The data extraction from each area can be performed based on the horizontal and vertical projections of the histogram. For the answer checking purpose, the number of black pixels in each answer block is counted, and the difference of those numbers between the input and its corresponding model is used as decision criterion.

Pegasus Imaging Corporation [2] presented a Software Development Kit for OMR recognition from document images. The SDK supported template recognition mode and free recognition mode. An OMR field is defined as a rectangle area containing a specified number of columns and rows of bubbles to be evaluated. The SDK can scan the region horizontally and then vertically to locate the bubbles apart from the spaces between them. Then, based on the bubble shape specified, it scans the discrete areas of the bubbles, counting dark pixels to determine which bubble areas qualify as "filled in".

Hussmann S. et al [3] describes the design and implementation of an OMR prototype system for marking multiple-choice tests automatically. Parameter testing is carried out before the platform and the multiple-choice answer sheet has been designed. Position recognition and position verification methods have been developed and implemented in an intelligent line scan camera. The position recognition process is implemented into a Field Programmable Gate Array (FPGA), whereas the verification process is implemented into a micro-controller. The verified results are then sent to the Graphical User Interface (GUI) for answers checking and statistical analysis. However, the resolution and overall system design was not satisfying and lead to further investigation.

Hussmann S. et al [4] describes the development of a low-cost and high speed OMR system prototype for marking multiple choice questions. The novelty of this approach is the implementation of the complete system into a single low-cost Field Programmable Gate Array (FPGA) to achieve the high processing speed. Effective mark detection and verification algorithms have been developed and implemented to achieve real-time performance at low computational cost. The OMR is capable of processing a high-resolution CCD linear sensor with 3456 pixels at 5000 frame/s at the effective maximum clock rate of the sensor of 20 MHz (4×5 MHz). The performance of the prototype system is tested for different marker colours and marking methods.

Hui Deng [5] also presented an image based approach. In this approach, the questionnaire sheet is having two types of marks: solid marks and hollow marks. The solid mark is for system usage, defined as system mark. The hollow mark is to be filled by students for information recognition, so is define as information mark. Moreover, solid marks are

composed by two types i.e. circular-shaped and rectangular-shaped. The circular-shaped solid marks, which locate in top left and top right of the sheet, are used to correct the tilt of the whole page. The rectangular-shaped solid marks are defined as "flag points" in this paper, are used to search the coordinates of information marks.

The problem with the Pegasus technique is that in the school, the multi-choice answer recognition success rate cannot achieve the requirements of the examination and with the Deng's image based technique is, to get 100% precise recognition, more manual works need to be performed.

3. Proposed Technique

Proposed technique is a low cost solution of OMR process. It neither requires high cost computational machine (reader) for scanning nor expensive high quality paper. Also this is an image based technique which can be used in small scale industries, institutes and schools.

There are four basic steps in this proposed method:

(i) Template Designing.
(ii) Image Capturing.
(iii) Performing 2D transformation and scaling on the scanned image to align and size it correctly.
(iv) Finding marks on questionnaire.

3.1 Template Design

In this phase, a layout of the questionnaire, a template is designed using Microsoft word. Microsoft word is an application which can be learnt easily and also be used by non technical persons. A sample layout of template is shown in figure 1.

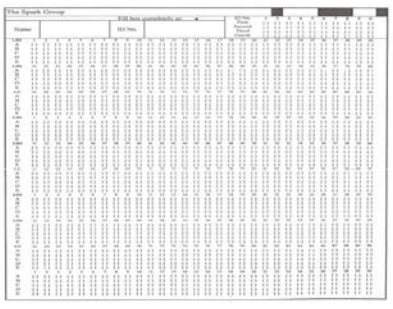

Figure 1. Layout of questionnaire

The designed template layout has a grid which helps in checking the alignment and scaling. All coordinates of template including top left corner, top right corner, bottom left corner and the bottom right corner of grid are saved in database. Also the aspect ratios of all the option fields are consistent.

3.2 Image Capturing

To capture the image of the questionnaire, flatbed scanners are used. These scanners allow users to work with prints, paper documents, and even three dimensional objects. Normally, the flatbed scanners take 10-20 seconds to scan an 8 x 10 inch image. This image is stored in JPEG format. The cost of these scanners lies in between Rs. 3000-5000, while OMR scanners (reader) cost Rs. 40,000-90,000.

3.3 Perform Transformation and Scaling

During the scanning process, if the form is not put properly on the scanner, or if the resolution of the scanner is not set to normal, the scanned image may be tilted or translated with respect to the original template referring figure 2.

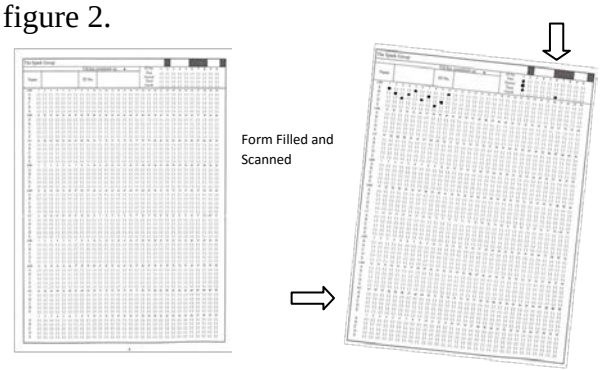

Figure 2. Scaling and Rotation Issues

This might also happen while photocopying the form (to get multiple copies of blank form). Such issues need to be resolved

3.3.1 Transformation

If the scanned image of the form is tilted, the rotation needs to be done. It makes use of the grid present on the form and calculates the degree of rotation and translation, then corrects it to match the standard template before any processing gets started. The coordinate positions of the standard template are already stored in database which is then used to identify the responses marked.
For resolving rotation, the steps to be followed are:

(i) Find the pixel coordinate value of top left and bottom left position of the scanned image of questionnaire form.
(ii) Now compare the grid of questionnaire to the grid of template. The grid of scanned image may be inclined by an angle Θ to the standard template. The grid of scanned image will be rotated by Θ to match with the grid of standard template.
(iii) The rotation angle Θ (shown in figure 3) of the questionnaire with respect to template can be calculated by the Eq. 1 :

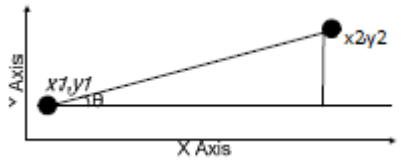

Figure 3. Rotation angle of questionnaire to template

$$\text{Rotation angel } \Theta = \tan^{-1}[(y2 - y1) / (x2 - x1)] \quad (1)$$

3.3.2 Scaling

If the aspect ratio of printed form is differ from the standard template, scaling is need to be done.For resolving scaling, the steps to be followed are:

(i) Pixel values of all the coordinates of the scanned image are stored in the database.
(ii) With the help of the coordinates of top left corner, top right corner and bottom left corner the height and breadth of standard layout and scanned image are to be calculated.
(iii) Now the height and breadth of scanned image are compared to the standard template and scaled to convert all coordinate values of scanned image of questionnaire into a uniform system.

3.4 Finding Marks

As all the coordinates of the template layout and scanned image of questionnaire are matched, marks recognition process becomes easy. All the marks on the questionnaire image would be ‘filled’ or ‘blank’. More than 70% random pixels of single mark are checked. If 50% or more pixel coordinates are colored then the mark is assumed to be “filled”. In single choice question if two or more than two marks are colored than the mark with higher percentage of colored pixel is considered to be ‘filled’.

The proposed architecture includes the use of PHP (version 5.0), MySQL for database storage, JavaScript for uploading scans, Adobe Dreamweaver CS2 for designing the interface. For image processing mainly two steps are followed i.e. checking inclination and then checking scaling. After alignment(rotation and scaling) of the questionnaire image, mark recognition is to be done and results are generated(referring figure 4).

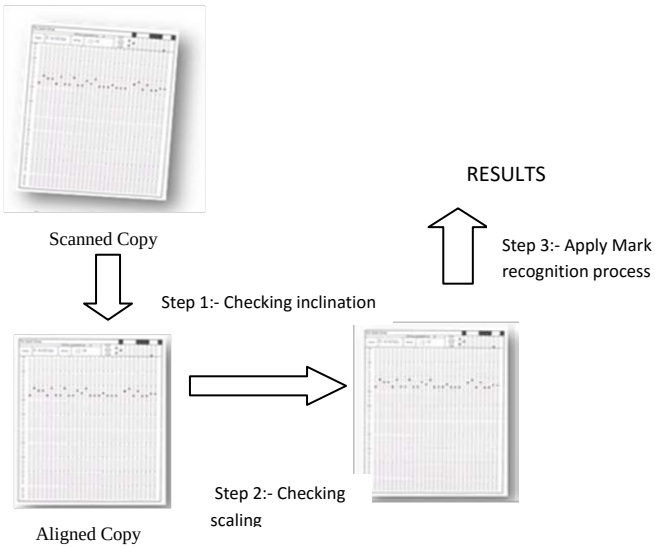

Figure 4. All steps of Image Processing

The technique discussed in this paper is a cost effective technique in comparison to old OMR technique. Old OMR technique requires extra high cost hardware (OMR Reader) and software. While this proposed technique is a light weight technique which require no extra hardware and can use common low quality plain paper (60-70gsm). Any low cost commercial scanners can be used for scanning purpose. Efficiency is comparable to old commercial OMR.

4. CONCLUSION & FUTURE SCOPE

The application developed will implement an efficient, accurate and robust software based solution to OMR technology. The input form to be used is to be printed on an A4 sheet just once and then can be photocopied to get multiple copies which make it even more cost effective. There is no need of an OMR scanner, a normal low cost scanner is used to scan the filled forms. The solution has been designed making use of Open source tools and technologies to keep it platform independent. The future work may include a functionality to generate the template on the fly. Also, the application cannot process all the forms simultaneously. This limitation can be done away with making use of OCR technology to read the student id from the form itself. Also barcode technology can be implemented to verify the authenticity of the form.

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