Barcode scanning from mobile-phone camera photos delivered via MMS: case study[1]

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Abstract. Price comparison services are commonly available via WWW interface and they belong to the most popular web-sites because their functionality is highly valued by users. However, in dynamic action of shopping, customers equipped in mobile devices have no time and conditions for precise describing products on their mini screens of PDAs or mobile phones. An alternative request for information about prices and availability of a product encountered during shopping might be sent to price comparator through MMS channel in the form of photograph with product's barcode.
In the paper we describe a series of experiments using mobile phones for sending camera-made barcodes and deriving numerical equivalence for product ID. Experiments were conducted on a set of barcodes in ideal and real conditions using a library for software barcode scanning. Collected results show two main sources of difficulties in using such a system: human-related problems and technical issues described in the paper. A separate issue is availability of barcode id in product description stored in price comparator database.

1 Introduction

Price comparison sites are popular among Internet users because they provide valuable functionality in a very simple form. It is a common practice for products to be identified by name and associated descriptive attributes. In the simple form, searching algorithms are based on selection of database records where user defined phrase is a substring of product name or product's description. The tool is oriented towards supporting intentional shopping, where users know the product.

The value of information provided by a price comparator has two aspects. Firstly, it is a price ranking which allows the customer to select the cheapest offer for particular product. The other benefit for the customer is increased confidence. The

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attribute is closely related to number of offers presented to the customer. Even if the customer does not decide to choose the cheapest offer, he may know how far from the optimum the price of the preferred offer is. High number of product providers and price offers for particular product is considered a measure of market penetration. The more offers are displayed on user's screen the better confidence he gets that his selection process is based on reach knowledge of market reality. This functionality, *increased confidence*, may be especially valued by mobile customers, who encounter a product in the market, put it in their shopping cart, but wonder if the price they see on product label is acceptable in the sense that it is *close enough* to optimal offers available for the customer in other shops. The understanding of *close enough* to optimal price is a function of particular shopper's preference model and circumstances in which he is shopping. A typical window-shopper is more likely to make analytical calculations and select another product provider (e.g. an e-shop) who can offer the same good at a better price than a person quickly looking for a swimsuit for tomorrow's training 10 minutes before the shop is closed. In the swimmer's case the price and it's distance from the optimal price offer for this product is less important than the need to obtain the product quickly.

A convenient access to price comparators is available via a WWW interface, usually designed to be seen on big computer screen. Even though mobile users equipped in PDAs or mobile phones have the possibility to read web-pages on their devices the interaction through small keyboard is difficult and error-prone. Quite often, in dynamic action of shopping, mobile customers have neither the time nor conditions for precise description products on their mini screens of PDAs or mobile phones. However, the devices are commonly equipped with a photo camera. An alternative request to price comparator application for information about prices and availability in various locations of a product encountered during shopping might be sent to a price comparator through MMS channel in the form of a photograph with the product's barcode. System's response sent to mobile device would provide the top of price ranking from offers for a product defined by its barcode. An approach, based on a social network as an information feed, to keep the data stored in price comparator up-to-date was proposed in [1].

Another use of barcode scanning from photographs delivered via MMS my be quick product request or referral marketing. An interesting business model for a new form of word-of-mouth referral marketing based on RFID (Radio Frequency IDentification) tags scanning was proposed in [2]. The current reality of European shops is that almost every product is labeled by a 1D barcode, while RFID tags are still in experimental use. Word-of-mouth marketing, where recommendation to buy particular product comes from a trusted person, can be supported by scanning a product's code and sending a request for an identical item to suppliers shopping system. Ordinary mobile phones are not able to scan barcodes but they are equipped with a digital camera. Making a photograph of a barcode label on sought product and sending it via MMS is much easier than searching for the identical product in text based price comparators. A similar scenario of buying products by sending a photograph of the product's barcode may be applied when the barcode is displayed on a billboard and people passing-by can make a picture of the code and order the product or express interest in particular product which is sent to seller offering the product. The request (barcode picture) sent via MMS identifies the product and phone number of the person who sent the request – an excellent information for merchandiser willing to sell the product and a very convenient way of shopping for the customer. This marketing channel becomes more and more explored, because *the cellphone is the natural tool to combine the physical world with the digital world* (C.Roeding cited in [3]). Barcode stored on mobile phone in form of an image (either photographed or sent to device in MMS) and displayed on phone's screen can be scanned. It opens a gate to use the technology to sell electronic tickets which could be validated by existing barcode scanners.

In the paper we collect our experience from experiments we performed on the way to develop an application capable to read product id from a barcode photo sent via MMS. Software developed in our experiment is available at [4] and everyone can run his own similar experiments. The software can also be used in training the user in making a photograph of a barcode in order to make the image readable for the scanner. Problems encountered in our experiments may be divided into two sets: human-related and technical issues. In the context of applying the system to a price comparison system a separate issue is availability of barcode id in product description stored in price comparator database.

2 Tools integrated in barcode scanner used in experiment

JBiedronka [4] is a Java application developed at Poznan University of Technology, Poland as a desktop program which can be used to simulate software scanning of barcodes provided on images stored in JPG or PNG files. The software was developed as a student project with intention for experimental use. The program integrates functionality provided in *J4L RBarcode Vision* [5] library and *ImageMagick* [6] in order to scan the barcode and enhance quality (if necessary) of the image.

The use of the *J4L RBarcode Vision* library for extracting barcodes textual equivalence from images was decided on several factors:

- the library provided support for a wide range of one-dimensional barcode type, which are most commonly used throughout the world for coding information about commercial products. i. e., the EAN-13 and EAN-8 are the recognized standards for GTIN (Global Trade Item Number) [7].
- at the time of development (Spring 2007) research over the Internet resources gave no reliable open-source libraries, so it was decided to use a trial version of a commercial product for the study. The chosen option has the disadvantage of providing no means of applying changes derived from the experiments, however, it does provide an advantage of being a library, which is used commercially in real-life situations, and, therefore, an apt target of scrutiny.
- additionally, a version of the library has been prepared to function with Java, which well suited the non-functional requirements for the project, as barcode scanning was supposed to be performed in that language.

In addition to the barcode scanning software a graphical library has been used to provide digital re-mastering, if it were to cause the images to be scanned correctly. The *ImageMagick* suite was selected for this purpose, as a portable, open-source solution with a command-line interface.

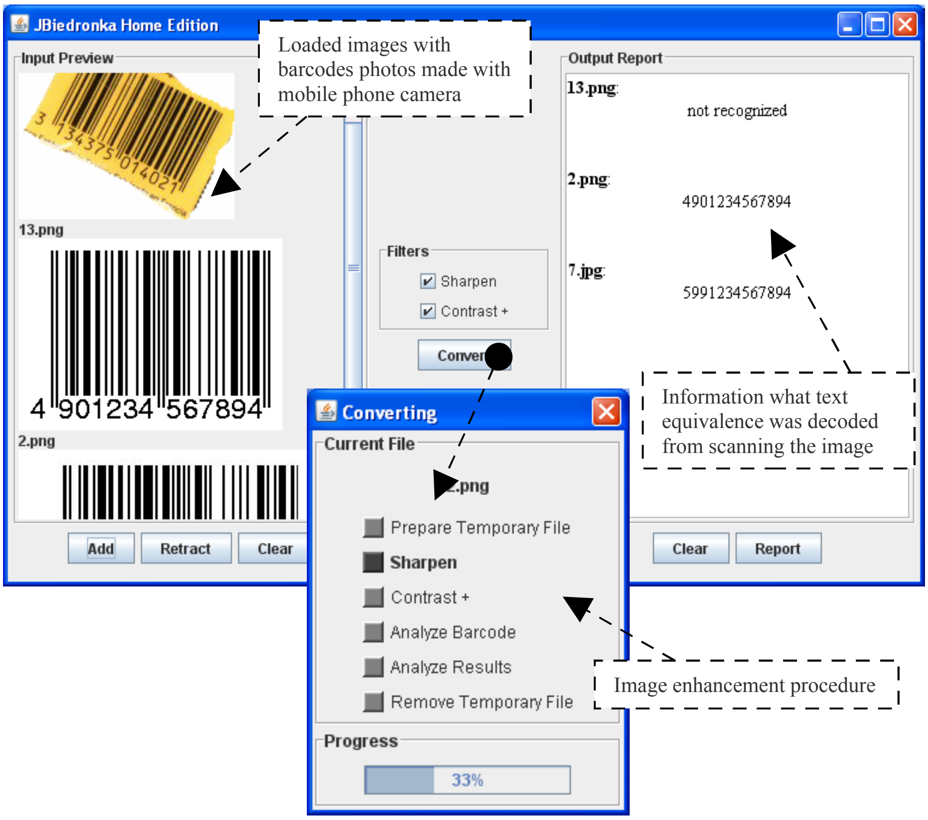

Fig. 1. *JBiedronka*: barcode image scanner designed for the experiment.

3 Examined objects

3.1 Camera items

A number of images gathered from various sources and of different characteristics were processed for recognition during the study. Similar cases have been grouped into sets, having similar characteristics and results. All the files mentions below are collected in [4] for evidence and comparison.

The most significant group of images that had undergone processing were the images gathered from mobile phone users, who were asked to take pictures of barcodes while in shopping venues. The users were not trained to how to make a good quality picture. Our intention was to observe how people understand *catching* a barcode on a photograph. In response we obtained a set of images, among which some were the photos of a barcode itself, there were photos of entire product with a barcode label and the most substantial part were photos where the barcode was in central part of the image but it was surrounded by graphics and text printed on given product (see fig. 2). The images were done using three models of mobile devices: Sony-Ericsson K510i (images real/sek510/*.jpg,) Motorola K1 (images real/mk1/*.jpg) and Motorola C651 (images real/mc651/*.jpg). This presented the most realistic cases might be expected were the service implemented for actual commercial use. Nonetheless the recognition failed in every presented instance.

Fig. 2. Sample real photographs of barcodes made with cameras built-into mobile phones.

Aside of not optimistic results of barcode scanning from photographs taken by mobile-phone camera, we faced a new problem: the picture sent by mobile user may contain much more than just a barcode. Our analysis let us to conclusion that people tried to have the barcode sharp on the picture, they naturally felt that sharpness of lines is a key issue in recognition process. However, mobile-phone cameras used in experiment offered no *macro* function [8] and it was not possible to make a sharp picture of small and close objects. In order to have the image sharper the users took pictures of objects at some distance which resulted in catching the barcode and its surrounding. Other problems identified in this experiment, that could be attributed to human skills (missing training) include: light reflects on barcode, barcode was not flat and taken under some angel which effected with perspective on the picture.

Another attempt was made with another group of images taken with a mobile phone camera of a Sony-Ericsson K510i (images filter/sek510/*.jpg). These instances were presented an improved quality to the previous group by applying a black-and-white filter to the images at capture and supplying improved lighting conditions, the images, however, were still heavily blurred. The results of recognition of this group were unsatisfactory – no images were recognized correctly.

3.2 Synthetic items

Following the results presented in chapter 3.1, cases were prepared to study the individual characteristics of pictures which influence the process of recognition.

Twenty images (see fig. 3) were presented to the barcode recognition software, which were obtained from a scanner device or computer-generated (images img/2.png, img/3.png, img/6.png, img/7.png and img/12.png) and present high quality. The barcodes are uniformly black, placed on white background, lean to no angle and present easily distinguishable, undisrupted straight lines. Such barcodes present an ideal case for the recognition software and produce good results.

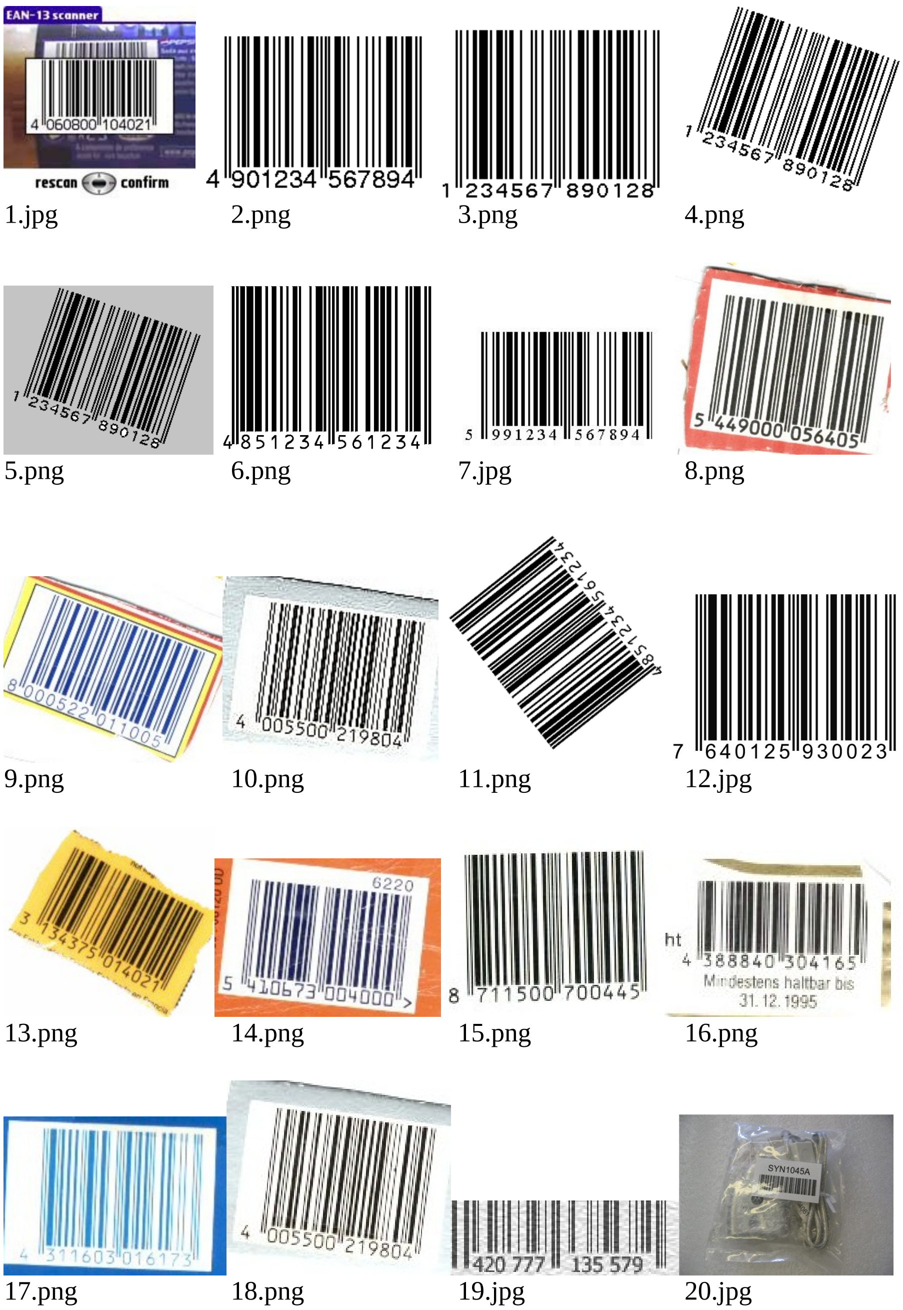

Fig. 3. Barcode pictures used in study of factors affecting quality of recognition.

An additional number of images obtained from a scanner device were presented for recognition, at this instance, with a skew ranging from about 45 degrees (img/4.png, img/10.png and img/13.png) to over 90 degrees (img/11.png.) The images img/4.png and img/10.png were recognized correctly, while img/13.png and img/11.png remained unrecognized. The evident cause of the lack of recognition of img/13.png seems to be the slight blur of the bars, visible especially well in the center section of the image resulting from the skew. The failure in reading img/11.png is apparently caused by rotation, which rendered the reader unable to locate the barcode.

A different set of images of similar origin to the one presented above were tested, however, these images include a multi-colored background, which results from being placed on an actual item (images img/1.jpg, img/5.png, img/8.png and img/9.png.) A skew may or may not be present at these instances. The barcodes from this set were all recognized correctly.

Next, a set of images were presented for recognition, which included a slight blur to the bars (images img/15.png, img/17.png, img/18.png) or different colors of bars (images img/14.png and img/16.png) in conjunction with some of the previous features. The results were unsatisfactory within this group as all the barcodes remained unrecognized.

Finally, an image with introduced noise was processed by the recognition software (image img/19.png.) The noise applied to the image took form of groups of pixels in the color of the bars dithered across the image. The recognition of such an instance proved to be impossible by software used in our experiment.

3.3 Digital re-mastering

Following the processing mentioned above two graphical enhancements were applied to the processed files in an attempt to improve the results of recognition. The re-mastering took form of applying the 'sharpen' function from the *ImageMagick* library followed by the conversion by raising the contrast of the image (see fig. 1). The former was meant to decrease the blurriness of the images, while the latter was to additionally resolve any problems with light. No significant improvement was noted, except for img/14.png, which, after application of both processes, became recognizable, despite the fact, that initially the blur caused otherwise.

Additionally, sharpening and contrast enhancement should be conducted with care, as some images may become unrecognizable only afterwards (i.e. img/8.png.)

4 Summary of the experiment

The data used for the study can be divided into two main categories: high quality and low quality images:

- The high quality images would be those obtained primarily by the use of a scanner or barcode generation software. Although it is possible for them to be skewed at large angles, these images are typically sharp, well focused and devoid of problems caused by bad lighting conditions, which are present in the other examined group. Consequently, the high quality images have had the best chances of being read correctly.

- The low quality images would be those obtained via mobile phone cameras; the images obtained this way present several additional characteristics: their overall quality is dependant on lighting conditions, types of photographed objects and the distance of the camera from those objects. Furthermore, they have varying levels of sharpness, contrast and focus. The barcode scanning software has additional obstacles to overcome during the scanning process, and, therefore, is less likely to succeed.

The reason why barcode photographs obtained from mobile-phone digital cameras belong to *low quality* set and they are hard to derive alphanumerical equivalence of barcode is missing *macro* function in cameras used in our study. Lack of macro function in cameras built-in mobile devices is a common problem. However, the *macro* feature may become available pretty soon, when improved cameras are used in mobile phones. It slowly becomes reality (e.g. Nokia N73 has capability of making good photographs of objects at a distance of 10cm).

5 Interpretation of results

Having inspected the results of the processing it is evident that its outcomes are not satisfactory to the needs of application of the system. Moreover, it can be seen that several factors are responsible for causing the inefficiencies. These factors stem from the technical aspects of the system, the faults of human operators of the cameras and the properties of the photographed objects.

Examining the ideal cases with incrementally added faults seems to indicate that the barcode recognition software can in fact overcome many interfering detail and still be able to present the correct codes. Some particular types of interference, however, pose serious problems – specifically, any blur, noise or a large rotation. While the latter problem can be easily overcome by instructing the operators of the cameras to try to align the barcode correctly, the previous two originate from the ineptness of the cameras themselves. Particularly, mobile phone cameras don’t seem to be able to take pictures of objects close-up, but are instead preset to taking pictures at a certain distance, which, in turn, is too far for the barcode to be legible. Additionally, the cameras tend to generate an amount of noise in case of bad lighting conditions, which prevents the bars of the barcodes to retain their widths in the eyes of the recognition software.

Moreover, the operators of the mobile phone cameras might cause problems in barcode recognition by inexpertly taking pictures of barcodes from too great a distance, at an angle to the surface of the object (which causes the relations among the widths of bars to be disturbed) or surrounded by too many details.

Furthermore, there exist problems caused by the environment, such as the lightning, or photographed objects themselves, such as the shape of the objects (for instance, round and spherical objects disturb the proportions of bar widths on a picture) or its texture (a glossy surface is bound to reflect light, so causing reflections in form of white stripes to appear on the barcode). These issues, however, are less visible in this study, as the process did not yet reach that phase, where this would become relevant, and, additionally, are a visible problem in other barcode scanning systems, not only those, which try to apply the mobile phone cameras to the process.

Finally, it is worth to mention, that digital re-mastering can be used to rid images of small blurs or lack of contrast, and may be tried if an image is not recognized, however, it should not be expected to fix any major flaws in the image. The extent to which sharpening and increasing contrast works is hard to determine, especially automatically by the recognition program, however they should not be performed on all images, as this might cause corruption on images, which would otherwise have been recognized correctly.

6 Conclusion and suggestions for improvement

The results seem to indicate that the application of mobile phones in the process of scanning barcodes is riddled with various, non-trivial difficulties, which stem from many areas. There are technical problems, human-related problems and problems related to the photographed object or its immediate environment, each of which need to be battled in their own unique ways.

There are several ways to overcome the technical problems related to mobile phone barcode scanning, and these draw either on the improvement of the camera used in mobile phones by way of allowing them to focus on objects close-up and improving their reaction to low light, or on the improvement of the technology of barcodes. The latter is applied sporadically throughout the world for coupons, where large two-dimensional barcodes are used instead of small one-dimensional ones, which provide more and better quality information for the recognition software. However, such an approach may prove difficult to implement for a system, which should be used for gathering information about shopping, which is already identified by one-dimensional codes.

The solution to human-related problems should require simple instruction, on how to supply better quality images of barcodes via a mobile phone camera. Whether such instruction were possible to conduct or effective it is difficult to determine, however it would, with high probability, not need to be excessively long or detailed, resulting in its increased efficiency, and just a few simple details are bound to enhance the quality of the image greatly (as the Pareto rule lets one believe.) Possibly, such instruction would also be useful in overcoming the problems related to the environment as well.

7 Application of barcode via MMS in marketing

Our experiments showed that commonly used mobile phones equipped with a camera without *macro* function are not able to produce images of barcodes in quality good enough to automatically decode the image and send response to the mobile user. However, using the same camera built-in mobile phone, it is possible to make a sharp photo of a larger object. It could be a barcode but presented in such a size that a distant photo can catch the image in condition ease to decode alphanumerical equivalence of the image. Our additional experiments showed that barcode image printed on A5 paper size are big enough be taken with mobile-phone camera and correctly interpreted by our software scanner. It opens a gate to provide customers with possibility of taking a photo of a barcode presented on a billboard or printed as an ad in a newspaper. It is easy to make a picture and send it via MMS to express customer's interest in particular product or use this communication channel for registration.

Customer's query sent from mobile device in form of an MMS containing a barcode image identifies owner of the device (mobile number) and product. It is possible to automatically reply such customer by sending him an offer corresponding to request. The system receiving customers' queries may also sort and schedule requests and pass them to personal customer assistant who may contact the customer.

When cameras built-in mobile phones become capable to make sharp photographs of as small objects as barcodes printed on products, the service of mobile price comparison should become available via MMS interaction. It is an easy and convenient way for sending queries, however, what came from our experiments, users must be aware of factors affecting possibility of proper image decoding. They are, for instance: light reflects and perspective on the image. Users require training and our software: *JBiedronka* available at [4] may be used for testing whether images of barcodes coming from a camera are readable for software scanner.

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