Study on Mobile Image Search*

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Abstract: **Visual-based mobile image search aims to provide a link between the physical and digital worlds by making the visual surroundings of the user "searchable" and objects in visual proximity "clickable". Providing the advantage of easy and fast querying, this type of search is rapidly gathering popularity in various applications. The efficient combination of the phone's sensors with image recognition technology makes mobile image search more than a simple shift from PC search to mobile. In this study we examine twelve existing mobile image search services with the aim of identifying the technologies and business models being used in them and analysing likely future developments in this field from a technological and socio-economic perspective.**

Keywords: mobile image search, techno-economic, study, business models, technologies, augmented reality, photo sharing

1 INTRODUCTION

One of the main goals of mobile search has been to enable users in finding location-based information by entering a word or phrase on their phone. In the last years, mobile content has changed with more and more multimedia content being available and even specifically created for mobile devices. This trend has motivated the development of mobile image search which is the type of search that puts images at the centre of user's attention. In this paper we study the most intriguing aspect of mobile image search that is based on visual queries. Visual-based mobile image search works like traditional (key-word) search but without having to type any text or go through complicated menus to initiate the search process. Instead, users simply turn their phone's camera towards the item or object of interest and once the system recognizes the user's target and intentions it can provide further information (e.g. the restaurant menu) or services (e.g. reserve a table for dinner) [1], [2]. Despite the many similarities, mobile search is not just a simple shift of PC search to mobile devices since it is connected to specific technologies e.g. such as mobile broadband and mobile content [8]. In this context, mobile image search has been the subject of many recent research efforts [3], which aim at integrating mobile augmented reality [4] and outdoor coordinate systems [1] with visual search technology.

One advantage of visual-based mobile image search is that it is way faster than conventional searching methods. The reason for this is that even highly trained typists who manage up to 900 characters per minute on the PC keyboard, start working at a very low pace when it comes to cramped keyboards and touch screens on mobile phones. Moreover, people may prefer snapping a photo than using words to describe its content, especially when the object of interest is difficult to describe. Sometimes indeed a picture is worth a thousand words. This is why a mobile device equipped with a camera having visual-based search capabilities, may be very suitable to search and find information in many contexts and applications.

According to [7], in 2006, smartphones accounted only for 6.9% of the total market, while in 2007 the market segment reached 10.6%. The total annual sales of mobile devices reached 1,275 million units in 2008, with 71% of them sold with data facilities, of which 15% (of total sales) correspond to smartphones. In Europe, 280 million units were sold in 2008, of which 19.3% where smartphones and 65.5% enhanced devices. It is evident that camera-enhanced, hand-held devices are spreading at a very fast pace. Moreover, according to a leading market research firm eMarketer, by 2011, mobile search is expected to account for around $715 million. Moreover, according to a recent study (April 2011) [14], among 5,013 US adult Internet users at the end of 2010, "71% of smartphone users search because of an ad they've seen either online or offline; 82% of smartphone users notice mobile ads, 74% of smartphone shoppers make a purchase as a result of using their smartphones to help with shopping, and 88% of those who look for local information on their smartphones take action within a day." Earlier this year, [15], [16] predicted that mobile search would soon reach 10 percent of all the search impressions its clients were seeing. Based on these studies, in the end of April 2011 the mobile impressions accounted for 10.2% of all paid search impressions (desktop + mobile). These and other recent studies clearly show signs that mobile search is moving mainstream and gaining momentum. Unfortunately, as far as the authors of this paper are aware, there are no publicly available figures about the size and dynamics of the visual-based mobile search segment of the market. However, we can reasonably expect that this segment will scale proportionally to mobile search, creating new opportunities and offers. This is also advocated by the fact that major players in the mobile communication and search industry like Nokia and Google, are investing a lot of effort in the mobile image search concept in order to take advantage of the expanding mobile ad market.

2 ARCHITECTURE & TECHNOLOGIES

The majority of existing mobile image search applications employ a client/server architecture with a data pool lying behind the server (Figure 1). Cell phones act as clients which capture images of the object(s) of interest and send queries to the server. The server, on the other hand, is responsible for analyzing the image, identifying its content, retrieving

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relevant information from the data information pool and sending it back to the client. Below we briefly describe each of the aforementioned steps and list the currently available technological solutions, however the interested reader is encouraged to read [18] for an insightful look on mobile visual search technologies.

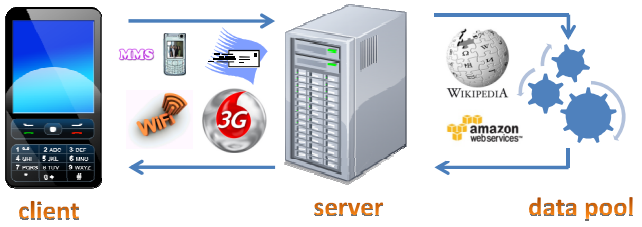

Figure 1: Client/Server architecture for mobile image search

2.1 Client/server communication

By communication we refer to the client's need for transmitting to the server the image depicting the object of interest or just a representative subset of it, as well as the server's need for sending back to the client the related retrieved information. Due to the low speed restrictions of **GSM/GPRS** networks and the limited capabilities of older cell phones, the first mobile image search applications relied on the use of **MMS (multimedia messaging)** or **e-mail** services to send the image file. Then, after processing the image and retrieving the relevant information, the server responds to the client's query by enclosing the related information in an SMS or e-mail that is send back to the user's cell phone. It is evident that when operating on a low speed network, it is impossible for the mobile image search application to perform the aforementioned process in real time. On the other hand, building on the advances of broadband networks and the new features offered by smartphones, the most recent mobile image search applications rely on the use of **Wifi** or **3G networks**. In this case the client/server communication is transparent to the user since all necessary communication actions are handled by the application. The network speed is sufficient for transmitting large blobs (binary large objects) like images, as well as receiving the necessary information, all within a few seconds.

2.2 Client Interface

The main factor differentiating the experience offered by each application is basically the mechanism used to capture and sent the visual content to the server, as well as the mechanism used to display the received response. In this context we can distinguish between three different types of user experience: a) **Menu mediated interaction** where the user needs to switch between different application menus (e.g. MMS, SMS or e-mail menu) for both sending the captured image and viewing the received response; b) **Snap-based interaction** where a single interface is used both for sending the image (i.e. by pressing a button) and viewing the received response (i.e. usually through a dedicated place in the screen that is reserved for this purpose); and c) **Real-time interaction** where the user is offered an augmented reality experience with meta-tags popping up as he turns his camera phone towards the object of interest. Although most intriguing, the real-time experience still faces some important technological challenges, which is why the vast majority of existing mobile image search applications employ a snap-based approach.

2.3 Processing load

Processing load refers to the place where the captured image is processed. In the case of **client-side** processing the captured image is processed by the smart phone processor and a set of representative features is extracted [1]. These features are subsequently transmitted to the server for retrieving the relevant information. Although reducing the network load and speeding up the whole process, client-side processing is only feasible when the smart phone is equipped with enough processing power to extract the necessary features. On the other hand, in the case of **server-side** processing, the full image file is transmitted to the server that takes care of extracting the representative features and retrieving the relevant information [5]. The server-side solution removes the processing burden from the client device at the expense of increasing the network load and response latency.

2.4 Image content recognition

Although it is common practice among mobile image search companies not to disclose many details concerning the utilized technology, we can safely assume that image content identification is usually accomplished using one or more of the following approaches: a) **Nearest neighbour based approach**. Using content-based image retrieval techniques the query image is matched with one or more very similar images with known content. Then, based on the assumption that very similar images depict the same content, the information returned as a response to the client's request is the information associated with the matched image(s). Nearest neighbour is the most scalable approach for image content identification and is currently adopted by the majority of existing applications. However, it requires the indexing of a significantly large number of images with known content before starting to produce meaningful results; b) **Object recognition based approach**. Using the principles of pattern recognition a model is learned for every object. The query image is examined by all available models and the objects with higher confidence are considered to be depicted in the image. Object recognition is the most flexible approach for linking between the physical and digital world, but the typical rates for correct object recognition in unconstraint environments [17] are still inadequate to support a general-purpose mobile image search application. Moreover, given the high training cost for learning the object recognition models, this approach is only applicable in constraint domains with a limited number of objects; c) **Watermarking based approach**. Using encryption techniques that rely on the statistical characteristic of the image at pixel level, a content identifier is embedded into the digital image before it is made public. Then, when the server receives the watermarked image

as query, a watermark detection mechanism is used to decrypt the content identifier and retrieve the relevant information from a database. The watermarking based approach is favoured in cases where the recognition robustness is a critical factor of the application. However, the major drawback of this approach is that content identification cannot be performed on images that have not been watermarked, which makes it applicable only in cases with full control over the distributed content. d) **Human computation based approach**. Some of the existing applications for mobile image search use human annotators to facilitate the identification of image content when the automatic detection mechanisms fail.

3 USER NEEDS AND USAGE

Mobile search constitutes one of the most attractive services offered by smarthphones that users primarily use while they are on the move. They use it when they don't have access to a PC (e.g. waiting in the airport, etc.) or when it is more convenient using their phone (e.g. it would take longer to switch on their PC). In addition, mobile image search is particularly useful when the user's location and surroundings information is important for retrieving relevant results. The basic motivation for using mobile image search is the ability of visual content to transfer rich semantic information that is either too complicated or too ambiguous to be described and expressed with words. Indeed, if the user is not sure how to describe something with words it may be easier to search with a picture. Moreover, it is also common to use image search services with embedded OCR capabilities for translating foreign billboards and traffic signs. Finally, the ability of mobile image search to turn the world around us into semantic links (pointing to news, websites, special offers, etc.) with the ease of a photo snap, is what makes this service way more attractive than text or voice-based search that are more demanding from a user input perspective.

Mobile image search still occupies a small fraction of the total number of issued queries, but this is changing very rapidly. As reported in [9], although image-based interfaces are currently not considered as one of the critical components of mobile search, the situation is expected to change in the near future. Based on the findings of the report [9], image-based interfaces are expected to acquire an equally important role with text-based interfaces. This change will be further boosted by the technological advances in the relevant research areas that are expected to offer more robust and scalable services.

Finally, given the widespread use of mobile photo-sharing services and the rapid growth of augmented reality applications, mobile image search is expected to become the core functionality of many future applications such as image-based browsing of personal photo archives. Indeed, as consumers generate an increasing number of digital multimedia content, finding a specific image, audio clip or video becomes a non-trivial task. Mobile device users typically browse their personal multimedia libraries by scrolling through image thumbnails or by manually organizing them in folders and browsing through the folders. As a consequence, rich multimedia content is lost in the users' personal repositories due to the lack of efficient and effective tools for tagging and searching the content. Motivated by this fact current studies have started to look at how the technological advances of image search can be incorporated into a mobile environment [10], [11].

4 BUSINESS MODELS

Since mobile image search is still in its early stages of development and deployment, a business model that could render sustainable this type of service has not been established yet. The currently existing applications can be mostly considered to be in experimentation phase both in terms of the employed technologies as well as the potential business opportunities. Attempting an overview of the currently existing approaches we can distinguish between business models that provide **intangible** and **monetary benefits** [6].

According to the **intangible benefits** model, free services are provided to users in exchange of their attention, loyalty and information. Then, the company can somehow "monetize" the attention, loyalty and information of users. For instance, mobile image search can be used by a company as an attractive application for engaging more customers to their client base. Profit does not derive directly from the use of mobile image search but from attracting more customers to use a paid service that incorporates the search functionality as an additional feature. This model is typically followed by the **mobile telecommunication operators (e.g. Vodafone)** and **mobile vendors (e.g. Nokia)**. An **intangible benefit** model is also followed by many software companies that use mobile image search to demonstrate their technological competence and expertise in the field to attract potential new customers.

On the other hand, the **monetary benefits** model comes up in the majority of relationships where a transaction or a subscription process takes place and customers are required to pay in exchange of services or goods. This model is usually implemented through **fixed transaction fees**, **referral fees**, etc. Within mobile image search one aspect of the monetary benefit model is primarily based on **advertising** that uses visual search to promote services and goods. In this case advertisements related to the content of the query image are displayed to the user's cell phones, in a way similar to Google Adds. Another aspect of the monetary benefits model is based on charging for access and use of the search and recognition engine, i.e. **Software-as-a-Service (SaaS)**. One typical example of this model is the SmartAds service offered by Kooaba. With this service Kooaba allows its customers to turn their print ads into clickable links prompting readers to acquire more information about the product. The SmartAds functionality consists of: a) a Query API that is offered for free (with a request limit per day) and allows issuing requests to the existing database of objects; and b) Data API that requires an account and allows customers to upload their own print ads into the existing database. A revenue stream is generated by charging for the use of the Data API, or the Query API with no request limit. A similar approach is followed by IQ Engines, where customers are offered the possibility of uploading their own photos in the IQ Engine

database and issuing queries though their mobile application using a Query API. In the same spirit the TinEye Commercial API allows users to issue queries on the Tin Eye database after purchasing a search bundle. Finally, another aspect of the monetary benefits model, that is less flexible than SaaS, is based on signing explicit contracts with the marketers in the context of a **product promotion campaign** such as the Nokia interactive campaigns launched using Snap2win, or the partnership between LinkMe Mobile and the Guthy-Renker Japan's Proactiv product line. In this case the mobile image search company collaborates with the advertising agency in order to set-up a campaign that uses the core functionality of mobile image search to attract users' interest.

Thus, we can see that there are **mainly three business models adopted by the mobile image search companies**. An **advertising-based model** that relies on the relevance between the query image and the registered adds, the **Software-as-a-Service (SaaS) model** that relies on charging the customer for extending and querying the database of objects, and the **contract-based model** where an advertising agency employs the core mobile image search functionality in the context of an advertising campaign. Our estimate is that even if the contract- and SaaS-based models are currently very attractive for the companies offering mobile image search services, this is primarily because image recognition technology is still rather immature and can only function robustly in restricted domains. In many cases it has also to be tailored to specific needs of the client. Thus, the customer has no option but to pay for making its content searchable, since the general purpose search engines are still inadequate to satisfy the requirements. However, with the advancement of image recognition technology we anticipate that the advertising-based business model may become dominant in the mobile image search market.

5 CASE STUDIES

In this section we briefly describe the functionality and the adopted business model for twelve mobile image search services. More details about these services (applications) can be found in [13].

The service offered by **Kooaba** (www.kooaba.com) receives a snapped image as query and displays related information, further links and available files. The complete Kooaba system is composed of three key ingredients: image recognition technology, content delivery to the user, and automatic crawling of a large reference database of objects. The prime business model adopted by Kooaba is a SaaS-based model where the customer relies on the image search functionality to turn print ads into clickable links.

oMoby (www.omoby.com) offers a shopping service that helps users find information about products by snapping a photo, such as links to retailers offering product information, reviews, prices, and more. The image recognition functionality of oMoby relies on the technology developed by IQ Engines (www.iqengines.com) to identify and label photos. The business model adopted by oMoby is a SaaS-based model, which is implemented through four APIs (i.e., Query API, Update API, Training API, and Result API).

Mobile Acuity (www.mobileacuity.com) provides a service that aims at using the camera phone as an innovative mobile marketing tool and as a new way to search for digital content by pointing and clicking. Their Snap2win mobile marketing platform allows consumers to connect with a brand by pointing their camera at an advertisement or product. Snap2win was launched in 2007 and has quickly been adopted by a number of leading global brands as part of their mobile marketing strategy.

The **LinkMe Mobile** service (www.linkmemobile.com) aims to turn images into hyperlinks, encouraging consumers to interact with brands, advertisements, or products. LinkMe Mobile works mainly with brands, agencies, content owners, publishers, retailers, and carriers in creating new communication opportunities with consumers. Revenue streams are generated by executing the contracts offered on the basis of advertising campaigns.

The service offered by **SnapTell** (www.snaptell.com) enables consumers to access marketing content and information on the go. The technology adopted by SnapTell treats the problem of image recognition as a problem of matching a query image against a database of images. The adopted business model is a contract-based model that consists of partnering with marketers in order to create high-impact campaigns and to drive brand awareness and loyalty.

Point & Find (pointandfind.nokia.com) is a service offered by Nokia that uses visual search technology to let users find more information about the surrounding objects, places, etc., in real time. Nokia Point & Find is based upon image processing and automated object recognition technology, allowing the creation of worlds with enhanced objects. However, there has been a decision recently by Nokia to integrate Point & Find's underlying visual search and augmented reality technology in a way where consumers can access it as part of their service experience. Thus, the revenue stream will not be generated by partnering with the marketers, but from using mobile visual search to attract more users to the Nokia community.

GazoPa (www.gazopa.com) is a service that allows users to search images from the web based on the user's own photos, drawings and keywords. One interesting application that is based on the aforementioned technology is GazoPa Style Visual Fashion Search (http://style.gazopa.com/). It is a visual product search site that enables users to browse and search for similar fashion items easily. The revenue stream for GazoPa is most probably generated by charging referral fees when a user is redirected from GazoPa Style Visual Fashion Search to the respective on-line fashion store.

Google Goggles (www.google.com/mobile/goggles/) is a mobile application that lets users search the web using pictures taken from their mobile phones. It can be used for things that aren't easy to describe in words since there is no need to type or speak the query. As for the business model, it is interesting to see what Google's plans for generating a

revenue stream out of this service will be in the future. In 2010 we saw the acquisition of PlinkArt by Google, an application for identifying, discovering and sharing art. More recently, like.com was also acquired by Google, which is an automated cross-matching system for clothing. Both acquisitions show the company's intention to extent the recognition capabilities of Google Goggles and possibly employ the successful business model of Google Ads by displaying advertisements relevant to the user's visual queries.

CLIC2C (www.clic2c.com) is a service that enables mobile phone users to interact with their physical environment emulating the experience of online content access, search and discovery. It can transform the information printed on paper (newspapers, magazines, catalogues, posters, and packaging) in dynamic multimedia content to be displayed on the mobile phone, using the technology of digital watermarks. The business model adopted by CLIC2C is a contract-based model where revenue streams are generated by partnering with the marketers in the context of advertising campaigns.

The **WeKnowIt image recognizer** (www.weknowit.eu/wkiimagerecognizer/) is a service that provides the user with detailed information on the location and name of a POI (Point-of-Interest) that he has just photographed. It works by just snapping a photo of the surroundings and uploading the image. Then, the description of the location retrieved from Wikipedia is displayed on the user's mobile phone. A revenue stream for the WeKnowIt Image recognizer can be generated by helping touristic agencies or governmental organizations to make their touristic campaigns more attractive or even allow the visitors to obtain a radically different sightseeing experience for a small fee.

Wizup (http://www.wizup.mobi/) is a mobile audio-visual application that is able to listen to radio stations, or understand images from magazines and deliver relevant multimedia content to the mobile's screen. In what refers to the envisaged business model, it seems as if Wizup aims at generating revenues streams by allowing the marketers to enrich their advertisements with additional info.

Finally, **TinEye** (http://ideeinc.com/products/tineyemobile/) is a reverse image search engine that can be used to find out where the query image came from, how it is being used, if modified versions of the image exist, etc. One mobile application that uses this technology is Snooth. Snooth (http://www.snooth.com/iphone-app/) is an application that allows the user to take a photograph of a wine label and find the closest store that stocks the selected wine, as well as the prices in each store it finds. The business model adopted by Snooth is based on advertising.

6 SERVICE COMPARISON AND TRENDS

Table 1 compares the twelve mobile image search services we examined in terms of the employed technology, the target domain and the adopted business model. It is clear that image recognition is the dominant technology employed by the majority of existing services. An alternative approach is based on watermarking that brings the additional requirement of having to watermark the images before they are made public. Finally, crowdsourcing is another interesting approach for understanding the image content but little information is disclosed about the details of the mechanism.

Table 1: Comparison table for mobile image search services

SERVICE	TECHNOLOGY	TARGET USERS	BUSSINESS MODEL
Kooaba	Image recognition	Entertainment	SaaS-based
IQ Engines (oMoby)	Image recognition Crowdsourcing	Shopping	SaaS-based
Mobile Acuity	Image recognition	Consumers, Marketers	Contracting with marketers
LinkMe Mobile	Image and audio recognition	Consumers, Marketers	Contracting with marketers
Snaptell	Image recognition	Consumers, Marketers	Contracting with marketers
Point&Find (NOKIA)	Image recognition	Mobile users, Marketers	Engage more users in NOKIA experience
Gazopa	Image recognition	Shopping, Mobile users	Improving on-line shopping experience
Google Goggles	Image recognition	Mobile users	Advertising-based
Clic2c	Watermarking	Entertainment	Contracting with marketers
WeKnowIt IMG REC	Image recognition	Tourism	Touristic promotion actions
Wizup	Image and audio recognition	Consumers, Marketers	Contracting with marketers
TinEye Mobile (Snooth)	Image recognition	Wine industry	Advertising-based

The most popular domain that is targeted by the existing mobile image search services is shopping. Marketers use these services to increase brand awareness, launch clever advertising campaigns and discover new channels for transmitting focused information to the user. On the other hand, consumers are looking for new ways to make informed purchases and improve their shopping experience. Apart from shopping, mobile image search is also encountered in other sectors like entertainment, art, fashion, tourism, healthcare, etc. In entertainment the mobile users are offered an additional means to obtain information about their favourite program, movie or artist and even participate in on-line games that are set-up for advertising purposes. In tourism the use of mobile image search can help visitors in getting more information about the object of interest (i.e. a landmark or tourist attraction), while in healthcare its role can be to allow understanding complex scenarios much quicker and easier than free text [12]. Finally, in more specialized sectors like art, fashion and the wine industry, mobile image search acts as an exploration tool that helps users discover new content that may be of interest to them.

As for the revenue streams we have identified three different business models. The first model is based on partnering with the marketers in the context of an advertising campaign that makes use of mobile image search. In this case, the company's income comes from the contract signed with the advertising agency to offer its technological expertise. Moving one step further, some of the mobile image search companies have

adopted the Software as a Service (SaaS) model. In this case, the revenue stream is generated by charging for the use of an Application Programming Interface (API) that implements the mobile image search functionality. This is a highly flexible business model since there is no restriction on who gets to use the API, as long as they pay the respective fee. Finally, there is also the advertising-based business model that works similar to the Google adds paradigm. Although this model is currently adopted by only a small portion of the mobile image search companies, it is expected that sooner or later it may dominate this market in the same way with text-based search.

Finally, it is particularly interesting to investigate mobile image search in the context of two rapidly evolving sectors of the imaging industry. Photo-sharing services like Instagram (http://instagr.am), Path (http://www.path.com), Picplz (http://picplz.com) and Color (http://www.color.com) have been attracting a lot of attention recently. The widespread use of these services has dramatically increased the pace by which new image content is generated and shared, while the rich context in which these images are generated paves the way for improved or radically new image-related functionalities. Similarly, Augmented Reality (AR) is another sector that is rapidly gathering popularity. Indeed, substantial effort has been allocated on developing general scope augmented reality browsers like Junaio (http://www.junaio.com) and Wikitude (http://www.wikitude.org) that combines GPS and compass data with Wikipedia entries and overlays information on the real-time camera view of a smart phone, or Layar (http://www.layar.com) that uses the same registration mechanism (GPS and compass) and incorporates this into an open client-server platform. It is evident that mobile image search is gradually becoming an integral part of many smartphone applications that apart from the image itself are capable of providing rich contextual information ranging from GPS coordinates, to user profiles and social graphs. If we consider this fact in combination with the inherent weakness of currently adopted systems to achieve robust recognition in unconstraint environments, we can surely identify a research challenge for the image recognition community in using this contextual information for the benefit of robust recognition.

7 CONCLUSIONS

In concluding this survey, we should highlight the fact that the technologies for image recognition, and suitable search interfaces for mobile devices, are perhaps the two key elements for the success of mobile image search. Concerning the employed business model the majority of the existing companies doing business in this market follow a monetary benefits approach where revenue streams are generated either by contracts signed in the context of a certain advertising campaign, or by charging fees on the basis of a SaaS model, or both. However, this is expected to change as image recognition technology evolves, perhaps favouring a business model where profit is not derived directly from "selling" the image search functionality but from capitalizing the user's loyalty and trust established in using the search application (e.g. advertising-based model). Finally, we can also predict that the constantly growing interest around mobile photo sharing and AR applications will soon motivate existing and new mobile image search companies to enhance these applications with image-based searching functionalities, as well as the research community of image recognition to investigate ways of exploiting the rich contextual information offered by these applications.

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