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# DIGITAL IDENTIFICATION OF ORGANISMS ON MOBILE DEVICES: PROGRESS AND PROBLEMS

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***Abstract:*** *The identification of organisms, which was traditionally based on "classical" paper-printed identification keys, is facing a true revolution. The development of interactive, digital identification keys renders identification possible not only for experts, but also for amateurs. Furthermore, smartphones and tablets equipped with digital identification keys permit to carry out identification directly in the field. This paper discusses the progress from the first applications for PDAs (Personal Data Assistants) to those for modern smartphones and tablets, the potentialities and the open problems.*

***Keywords:*** *biodiversity informatics, citizen science, smartphone, tablet*

## 1. INTRODUCTION

Biodiversity is becoming a mainstream issue in the world of formal education and life-long learning. However, teaching and learning biodiversity often requires to address the problem of identification. Identification was traditionally based on the use of dichotomous (rarely polytomous) keys, mostly printed in the form of book and written by experts for experts [1]. These keys are usually organised following the scheme of biological classification: they first lead to families, then to genera, and finally to species. The characters used to discriminate among higher taxonomic ranks are usually 'difficult', both to observe and to appreciate. The consequence is that most of the classical identification keys can be hardly used for educational projects and for citizen science [2-3]. Technical jargon and the taxonomic arrangement of keys are the major obstacles to the identification of organisms for a non-specialised audience.

Since the beginning of the computer age, several researches have faced the problem of identification [4-12], resulting in a high number of digital identification keys, which range from simple "translations" in a digital format of classical paper-printed keys, to complex databases of morphological-anatomical data, distributional-ecological information and multimedia objects (images, sounds movies, etc.). The latter approach can overcome most of the constraints of paper-printer keys, because:

- The computer-generated keys do not necessarily follow the scheme of biological classification, and can give higher weight to "easy" characters. Especially in the dichotomous interfaces, if "easy" characters are used first, the key becomes easier and can be used by amateurs as well [12];
- they can be easily customised to any subset of species (e.g., a given area, a schoolgarden, etc...) [13-14]. The presence of a high number of species, especially if closely related, forcedly requires the observation of "difficult" characters. However, closely related species often live in different places or habitats, and can be often separated on the basis of distributional or ecological information;
- they can make an almost unlimited use of resources such as pictures, drawings, hyperlinks, videos (for animals), which is hardly possible in paper-printed keys [15];
- they can make use of different query interfaces: dichotomous, multi-access, multi-entry, etc., customised to the levels of expertise of different types of users [16]

Digital identification keys can now potentially target a much wider audience than classical keys, from elementary school children to citizens interested in discovering nature and biodiversity. The digital keys available in the Web have a great diversity of formats, contents, and query interfaces [16]. However, the Web can be not the best medium for an identification key when carrying out identifications in the field, due to missing or weak internet connections. Digital keys can be stored on optical disks (CD- and/or DVD-Roms), and used on laptops. While born to be portable, laptops are neither as light nor as portable as modern mobile devices, such as smartphones and tablets. These devices have performances similar to those of modern Netbooks, a good storage capacity, and screens which are clearly visible even in full sun. For this reason, their use is changing the way biodiversity is

studied in the field. The development of digital identification keys on mobiles is only at the beginning, and their full potential is still largely unexplored.This paper deals with the progress from the first applications for PDAs (Personal Data Assistants) to those for modern smartphones and tablets, including open problems and future scenarios.

## 2. FROM PDAs TO SMARTPHONES AND TABLETS

The first approaches to the development of digital identification keys for mobile devices focused on the use of PDAs (Personal Digital Assistants) [17-18]. These devices were born to be simple portable agendas, but rapidly evolved, including different and more complex features. With a PDA it became possible to surf the web, retrieve the coordinates of a point, view images, listen to music, etc. Several applications for these devices were developed, mostly for being used indoor, such as in museums and temporary exhibitions. The first examples of digital identification keys for PDAs were produced both for PalmOS [19] and Windows Mobile devices [17-18, 20]; Those for the latter pragmatically were in the form of simple stand alone versions of existing dichotomous keys, and made them usable offline by Web browsers. This was possible because a dichotomous key can be easily translated into a sequence of HTML pages linked together, each of them with a dichotomy or a taxon page.

With the increasing diffusion of smartphones, the efforts in the development of mobile keys focused both on Symbian and Apple iOS devices. While on Symbian devices it was possible to use PDA packages, iOS smartphones introduced the concept of "application", i.e. a package of software developed to be installed and used specifically on a given Operating System, following some rules provided by the OS producer. In the case of Apple iOS, the applications need also to undergo a "revision" before the release. A first approach in the generation of identification keys for Apple's iOS devices (iPhone / iPad / iPod) was the conversion of PDA packages into iOS applications. However, this solution, initially accepted by Apple, has been deprecated as of 2011. Furthermore, Android, a new OS for mobiles with similar restrictions, equipping an high number of different devices, was developed by Google. Presently, Android rules the market with a share of ca. 50%, while iOS holds the ground with ca. 25%. For this resaon, new approaches to satisfy both platforms were developed, leading to solutions which allow the management of data from local databases. The use of a true database, which replaces the static HTML pages, allows the automatic generation of the screenshots, with an increase of the performance of the software, also in terms of response to commands [21].

## 3. PROBLEMS

While the evolution of mobile hardware, operating systems and applications lead to interesting developments, severeal issues are still to be addressed.

*Complexity of the production phase* - While at the beginning digital keys for mobiles were produced through simple and pragmatic approaches, today they must be developed on software packages to be installed and used on specific OSs. While this provides users with applications fully integrated in the OS environment, it also is a limiting factor for the production of these applications. The know-how to develop applications for both Android and iOS devices must be acquired, and constantly updated to follow the evolution of both OSs and hardware. For this reason, modern digital keys for mobile devices normally require the joint effort of both biologists and computer scientists.

*Applications size* - Both Android and iOS applications have a "virtual" limitation in size. As fas as Android is concerned, no application can overcome the size of 50 Mb. Bigger applications can be developed only by producing a "main" application, and several "patches", which must be downloaded separately and linked to the first one. In iOS, while there is no actul limitation in size, applications over 50 Mb can be downloaded only through a computer via iTunes, and not directly by the mobile device. Digital identification keys, being rich in images, easily exceed the size of 50 Mb. This problem can be solved, at least partially, by increasing the compression of images, but this eventually downgrades the quality of users' experience.

*Multiple platforms* - The development of applications for mobile devices must also face the problem of the existence of two principal platforms, Android and iOS, which hold ca 80% of the whole market (Nielsen Wire, http://blog.nielsen.com/nielsenwire/?p=31688; last visited: 2012/09/03). Other platforms could become relevant in the future (e.g. Windows Phone, currently holding ca. 2% of the market share), or were dominant, but are rapidly losing their share, e.g., Symbian, which held 47% of the market share in 2009 (http://www.blackberrycool.com/2010/02/23/gartner-release-breakdown-of-mobile-os-market-share/; last visited: 2012/09/03). This situation cleraly forces producers to develop different applications for each of the platforms they are willing to support, while trying to anticipate the main trends for the future.

*New devices* - Another important issue is the high diversity of hardware. Not only smartphones strongly differ from tablets in terms of screen size, resolution and proportions, and calculation power, but there is a great diversity among different types of smartphones and tablets. Especially as far as screen resolution and proportions are concerned, these differences have an influence in the development of applications. For example, it is difficult to use the same layout on devices with different screen proportions, because the application could appear "stretched" on one side or the other. Furthermore, applications containing images with an high resolution are useless on devices with a low screen resolution, while low-resolution images are a drawback for applications on high resolution devices.

*Network coverage* - The poor development of wireless networks, which are necessary for effective data retrieval, is currently one of the main constraints for the use of digital identification keys in the field. Stand-alone

applications, which do not require an internet connection, are forcefully limited in their contents, especially as far as images, movies and sounds are concerned. While a modern smartphone or tablet normally has 16 or 32 Gb of memory, stand-alone applications should require a moderate amount of storage space.

## 4. POSSIBLE FUTURE DEVELOPMENTS

The world of mobile devices is in a state of steady growth and diversification. The implementation of new functionalities, and the increase in hardware performance and battery life enable the development of increasingly sophisticated software. While it is difficult to make realistic hypotheses on future developments, it is possible to define some issues which will probably be addressed with the development of new and more effective digital identification keys for mobiles.

*User-generated content and social networks* – One interesting feature which could be integrated into digital identification apps for mobiles is the possibility to share user-generated content through social networks such as Facebook and Twitter. In the framework of the European project KeyToNature [10], it become clear that users are willing to be less „users" and more „authors" of user-generated content. Their new and original content can range from images of organisms taken in the field to annotations, and sometimes to complex ecological observations and / or data. An application hosting such features will probably introduce a revolution in the way biodiversity data are generated and shared.

*Context-aware identification* – Contextualization of content can strongly improve the effectiveness of a digital identification key. The digital application could reduce the list of taxa included in the key to only those which are actually present in a given area/habitat. This can strongly reduce the number of organisms in the key, making identification much easier. Practically all smartphones and tablets are equipped wiht GPS devices and can provide the position of the user to the application. In this case, the constraint is the exploration of the territory, i.e. the availability of reliable lists of organisms for each Operational Geographic Unit in which the territory can be divided. Without reliable lists, it is impossible to produce reliable identification keys.

*Automatical shape identification* – Another interesting issue is the possibility of recognising an organism by its image. Today it is possible to compare a picture of e.g. a leaf with an archive of images and retrieve which one is most similar. Such a technology could be coupled to standard digital identification keys to rapidly reduce the list of organisms by simply comparing the image of an organism with an existing database. In this case, the creation of a reliable reference database of images is the most difficult step to take.

## 5. CONCLUSION

The fast diffusion and evolution of smartphones and tablets has opened up new opportunities in the production and distribution of multimedia applications, including digital keys for the identification of organisms. The possibility of using these tools in the field can be useful for schools, and has also attracted the attention of natural parks and botanic gardens as a new e-way to advertise their biodiversity heritage. The request for identification keys on mobiles is steadily growing, and will lead to further developments, both in the number and performances of the applications. This market, new and still largely unexplored [23], will probably provide exciting opportunities in the next future.

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