

# Pre Print: A Cloud Computing Based Instructional Scaffold to Help People With the Down Syndrome Learn Their Way in Town.

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## Abstract

Intellectual disabilities are one of the main causes due to which people can seldom reach a completely independent living. Down syndrome is the world's most common chromosomal disorder and cause of intellectual disability. Cognitive development is usually delayed and learning difficulties persist throughout life. Typically, individuals with Down syndrome tend to have difficulty in abstraction, generalization and, in particular, with short-term memory. They often seem to forget learned skills from one day to the next, as previous learning is often not transferred to future experiences. This is a problem in every learning context, including mobility. Nevertheless, a large number of people with the Down syndrome can reach a good level of independence; many have a job and can move by themselves along known paths in town. These skills are traditionally learnt through a long training performed by expert educators in a face-to-face situation.

Within the Smart Angel project, a system based on cloud computing technologies and geolocation systems (both satellite and terrestrial) has been developed. The target users find in their Smart Phones a guardian angel that quietly supports them in their everyday life and is always ready to help in case of need. They can move freely around town knowing that, if needed, help can be asked at any time. Furthermore, the system supports specific activities where the users typically have difficulty as, for example, time management.

The Smart Angel system offers the users the possibility to learn the new paths in town by actually moving along them, avoiding the use of maps, which require a certain amount of abstraction. Furthermore, it offers the possibility to implement an instructional scaffolding approach: constant support is offered during the learning process, which is tailored to the needs of the user, with the intention of helping him/her achieve his/her learning goals. Researches have demonstrated that scaffolding helps learners with Down syndrome in their learning process by easing the burden of the short-term memory.

Educators and families are often overprotective and underestimate the possessed abilities. Smart Angel, by tracking the users' movements and showing them in real time to the educators in charge, allows more freedom and discoveries without leaving the individuals completely alone. They can therefore experiment the newly learnt skills and further develop them by moving autonomously and discovering new areas in town. Should unforeseen situations arise, they will be managed by the users with the immediate assistance of his educator.

The Cloud Based system stores all the users' data allowing the educators both real time monitoring on the maps and an offline historical analysis of the users' data to have information about their movements, the areas covered, and their behaviours: how much did they actually use the system, how often did they ask for help, etc. This gives the educators a better and more complete understanding of the real level of ability reached by the users allowing them to decide how much support is needed by the single learner. As the users' abilities grow, the educators gradually step back as the user gets more and more independent.

Keywords: Cloud Computing, Instructional Scaffolding, e-Inclusion, Disabilities, Cognitive Disabilities, Mobility.

## 1 INTRODUCTION

### 1.1 Intellectual Disabilities

According to the web site "Disabled World" [1], "Every year, one child in every 800 to 1,000 births will be born with a condition known as Down syndrome", as many as 5,000 babies are born with the Down syndrome, each year, in the United States only. Irving et al. [2], with a retrospective review on Down syndrome cases born in the United Kingdom in 1985–2004, did not find an overall change in its incidence. Increasing maternal age and

improved survival of children with Down syndrome have offset the effects of prenatal diagnosis followed by the termination of pregnancy and declining general birth rate. In Europe, we know that a minimum of 4.5 million people with intellectual disability are estimated to live in the 25 Member States [3].

Their life expectancy has increased considerably in recent decades, from about 25 in 1983 to nearly 60 today. Wu et al. [4] report a sudden increase in survival of babies with Down's syndrome from the 1950s onwards, causing a large proportion of people with Down's syndrome who were in their 40s in 2011.

A significant and growing number of adults with the Down syndrome will be present in the future years. Only a few people with DS is able to live completely on their own; many of them live at home with their families while only some live in group housing with staff that are available around the clock. In recent years, collective living has become more common, being an important step towards integration in the mainstream.

In any of the above situations, autonomous urban mobility represents a key challenge for this target population and since they have difficulty in generalization and conceptualization, it is difficult for them to acquire the abilities required to move around and reach relevant places on their own through conceptual learning. For instance, due to this lack of abstraction capabilities it is very difficult for them (sometimes almost impossible) to read maps. The possibility of embedding the training/ learning process for mobility within real life environments can be of great help since in this way they do not need to rely on abstraction processes.

Traditionally, the basic abilities for moving around town are reached after a long training under the guidance of educators. The process includes some preparatory instruction carried on in class and a long training in streets where the disabled learn specific paths to reach their places of interest (workplace, leisure areas, friends' homes, etc.).

For this target population it is particularly important to lay the foundations for what they have to learn with a variety of appropriate means/tools (educational games, for instance) but even more important is to propose a live-process where the subject is led and guided to acquire specific competence about the path(s) to be followed through multiple attempts [5]. This process should be exploited through accurate monitoring and scaffolding actions (from educators accompanying the subject to invisible controlling of their movements).

Within this, innovative ICT technologies can have a key role. With the use of localisation services, innovative ICT tools allow the user to move safely around town offering him a constant support and guidance, and helping him in some of the phases needed to acquire a new path. Such a support will never be completely automated since we firmly believe that the educators play a basic role that cannot be replaced by a computer, nevertheless, technologies represent a tool that can support all the learning activities supporting the educator's role.

This paper deals with an attempt to use cloud technologies and localization systems to support the mobility of people with the Down syndrome. This was done in the framework of the Smart Angel project. The main aims and key features of the project as well as the rationale behind it are described in this work.

## 1.2 Learning with Scaffolding

The term "scaffolding" has been introduced by D. Wood in 1976 [6] and it refers to those activities which support the student in performing a specific task which is beyond his reach independently. Scaffolding, therefore, implies the following:

- the presence of an "expert" who can give the needed support,
- a task that is located in the student's Zone of Proximal Development (ZPD) as defined by Vygotsky [7].

Furthermore, as Pea [8] argues, scaffolding, to be defined as such, needs to fade as the student's learning advances. The student's abilities increase and the goals become accessible in an independent manner; the needed help decreases until it is removed. In those cases in which there is no fading and the support is always needed to achieve the established goals, it is not possible to talk about scaffolding but rather of distributed intelligence.

For example, stairs can be defined as a scaffold, which allows people to reach the second floor, but such a help cannot be removed with time. People do not learn to fly and will actually always need the stairs to reach the upper floor. Some scaffolds are forever and do not fade, they are not aimed at learning but rather their objective is to make it possible to do a task that would otherwise be impossible. This is considered by Pea a distributed intelligence system, where lacking abilities are provided by other components of the system (human and/or non-human).

Usually, fading is managed by the teachers, who tailor their advice and support to the single learner needs in the given task. Computer based systems, in general, can offer some sort of scaffolding [9], but the fading is not

managed as well, furthermore the interaction with a human expert is an important element since it allows the expert to be a role model for the learner.

Scaffolding is recognised as a natural manner to support learning: informal scaffolding takes place in adult-child interaction. It has been studied by several scientist, first of all Wood [6], in the support given by the mother to her infant while performing several different activities from puzzle-solving to language acquisition.

This approach allows the learner to acquire the needed skills while actually working on the task, reducing abstraction and conceptualization, which are key elements for our target population. Furthermore, people with the DS often have problems in leaning transfer (i.e. applying old knowledge or skills in a different situation or environment [10]) and our approach eliminates this drawback since the new knowledge is learnt while actually working on the task.

As Yussof states [11], scaffolding has the following advantages, which are even more important in the case of a student with learning difficulties:

- It reduces the instruction needed to achieve the objective.
- It reduces the number of errors made by the student while learning.
- It reduces the negative feeling and frustration related to learning difficulties.

## 2 THE SMART ANGEL SYSTEM

### 2.1 Description of the Smart Angel Project

“Smart Angel” is an Italian regional project funded by the Liguria Region. The project started in November 2013 and will last two years [12]. It is oriented to support the full inclusion [13] of people with intellectual disabilities and has the main aim of providing accessible solutions [14] supporting their daily life and in-house independent living. The project name “Smart Angel” refers to a sort of guardian angel who is always at the person’s side ready to help if needed and supporting his everyday life.

Smart Angel focuses, in particular, on people with the Down syndrome, with the following objectives:

- Developing, wherever possible, the needed skills for an autonomous life. The guardian angel does not want to substitute the final user in his life but just aims at offering a smart support. Therefore, the user’s abilities are stimulated and the users are put in a condition where they are supposed to be as autonomous as possible.
- Supporting them in those everyday life activities that are particularly difficult to face because they involve their weakest cognitive areas. For example, time management in support of their everyday activities.

In the framework of Smart Angel the issue of mobility in urban contexts appeared to be crucial to promote and enhance the target users full autonomy; this means enabling intellectual impaired subjects to move around in the urban context and reach relevant places (workplace, leisure, sports...).

This objective is pursued in two different steps within the project:

- A pre-training phase in which the users’ basic skills are stimulated through several activities managed by the educators. Some Serious Games have been specifically developed with the aim of supporting this step [15] [16].
- A second phase in which the users start moving around their real town, initially supported by scaffolding activities defined by their educators which are then loosened as the user’s skills grow.

Fig. 1 shows the main components of the Smart Angel project. A central cloud based platform collects all the users’ data and connects the other elements of the system. Each user has his own smartphone, equipped with specific apps to allow him both to have support in his everyday activities and to help his movements around town. A combination of satellite and ground localization systems is involved to trace the users’ movement.

Cloud technologies, based on Microsoft Azure [17], allow the educators to continually monitor the users’ activities and intervene if needed. Data is collected during the use of the system and stored centrally, so that it can be analysed by the educators to have all the needed information about the use of the system by the single user.

Furthermore, data coming from the use of a set of Serious Games specifically developed within the project also is stored in the cloud system and used by the educators to have a deeper and more complete understanding of their users.

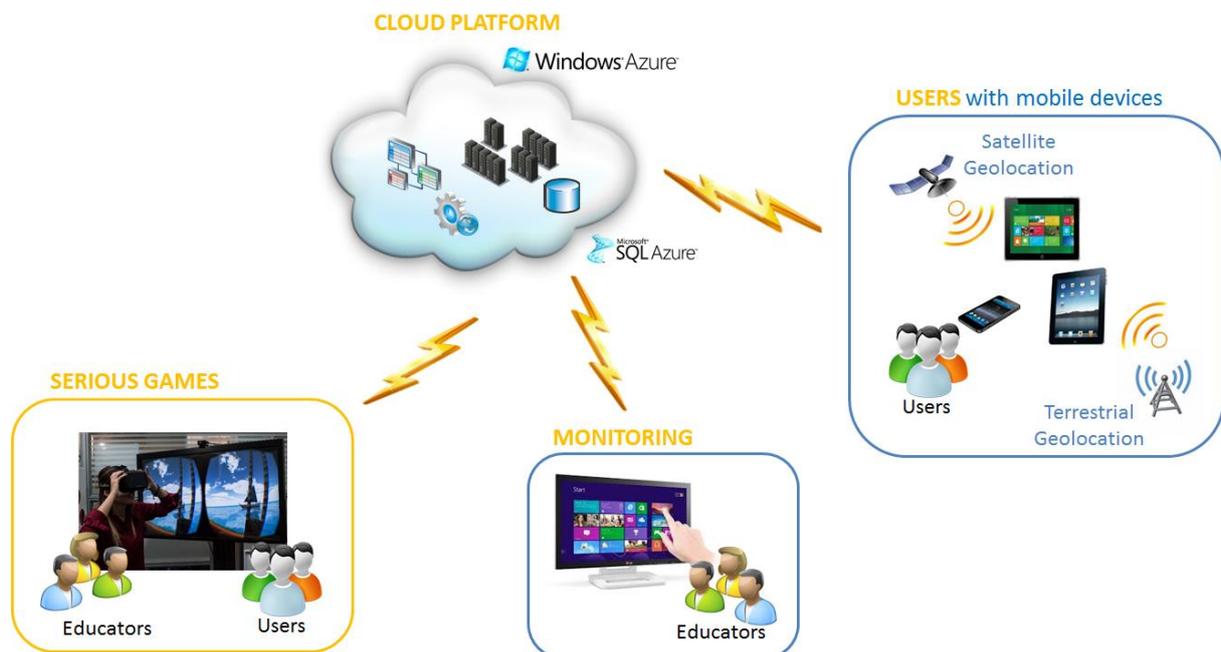


Fig. 1 – The Smart Angel main components

## 2.2 The Scaffolding Process

People affected by the Down syndrome have typically some retardation in their short-term memory and in all the abstract conceptualization activities. Therefore, they learn better when faced with practical situations, which belong to their everyday experience [18]. This regards also their mobility. The way to reach a place of interest cannot be learnt on a city map, it is necessary to accompany the person along the specific path and give him time to recognize and remember all the key elements, which allow them to move along the path without getting lost.

As soon as the final users are able to face the real streets: i.e. they have acquired the basic knowledge about street rules and the needed capabilities to recognize and avoid potentially dangerous situations, they start moving around town.

Their very first steps are always accompanied by their educators so that they can directly see the user's real performances. However, the constant presence of the educator throughout a long learning phase is both time consuming and limits the real independence of the learner. Smart Angel offers a mixed solution, in which the scaffolding activities can be carried out remotely, without the physical presence of the educators.

After the path to be learnt has been examined with the learner, the educator decides when it is time to leave the user alone and allows him to move autonomously along the new path. In case the user should need any help, Smart Angel is always present and help can be given immediately both automatically by the system or connecting the user with the educators.

The system intervenes automatically without the use of maps, which are usually difficult to understand for our population. Simple instructions, reminders and suggestions as to which will be the following area to reach are given when needed. Furthermore, if the user needs any further help, a phone connection with the educator is suggested.

At the very beginning, when the highest level of scaffolding is needed, the educators can follow in real time the user's steps on a remote map. They can therefore intervene as soon as there is a potential problem. For example, if the user starts moving along a different direction from the planned one, the educator can immediately call the learner on the phone and help him get back on track before he really gets lost. As the user's abilities grow, the scaffolding can be reduced and the user will then be completely autonomous in his mobility.

In this manner, the end users can learn their way by actually moving along it, practicing the recognition of the key elements that characterize the path (e.g. the squares and monuments which confirm being on the right path, the key points where to change road or the bus stops where to stop, etc.). The educators, on the other hand, can follow several users at the same time from a central position connected to the web.

The system is actually very useful also for those users who already master all the needed abilities and knowledge to move around by themselves. It may happen that the usual roads are closed due to road works, strikes, etc. Under these unpredictable circumstances, the system may have to be activated again in order to support a situation which, being more difficult than the usual ones, may move again in the learner's ZPD.

Furthermore, it happens that the user, who is completely capable of managing his own movements, may have to learn a new path. This can occur for several reasons: a new job, a new friend, an acquaintance moved house, a new swimming pool or a cinema, etc. In these cases, a new path has to be learnt and the educators may decide to use again some scaffolding activities in support of this new learning. Usually a lower level of scaffolding is needed compared to the very first movements.

The Smart Angel system can be therefore considered at different levels:

- *Performance oriented.* A level in which the main objective is related to the accomplishment of one single task. The user needs to learn a new path in town. It may be the first path that the user will manage by himself or just a new one that adds on to the entire user's knowledge of his town. The aim is helping the learner to move correctly along the pre-defined path without other human help.
- *Basic abilities oriented.* As the user learns new paths in town, his orientation skills increase along with other basic abilities: avoid getting lost, what to do in case it should happen, how to avoid street dangers, how to manage stressing situations, etc. At this level, the Smart Angel system becomes a support to the learning process, in which the final users actually become more independent in their mobility by mastering new basic skills.
- *Scaffold oriented.* Overall, Smart Angel offers its users a distributed intelligence environment, giving the learners permanent scaffolding for those activities that are out of their reach. In this manner, the users can perform better with the help of the system than they would by themselves acquiring a higher level of independence.

### **2.3 Analysis of the User Performance and Fading of the Scaffolding**

The role of educators and caregivers in all the learning phases is crucial. The Smart Angel system barely offers the technical possibility to support the learner in his movements, but the real needs of the user can only be defined by those who well know him, his needs and his limits. Within the project, which is still in progress, some general criteria as to how much and which kind of scaffolding is needed by the learner will be examined.

During the use of the Smart Angel system, data about all its usage is stored in a central database. The educators have then the possibility to access information about the movements of their users, how much the system has actually been used, how often help has been asked and which areas of town have been explored autonomously (if any). In this manner, the educators can have a much deeper understanding of the users' real abilities and independence. They may realize that the user knows his own town much better than they thought and can therefore let him have a wider independence. Educators use this knowledge, along with their experience and with the specific knowledge of that single user to define, moment by moment, the kind and the amount of scaffolding to be given.

Furthermore, the end users know that their Smart Angel is always there, ready to help. This means that, even if the educators have decided that no help is needed, if they feel that some kind of support would be appreciated, they are always free to activate the system and ask for help. This will make them feel more at ease, and allow them to explore some new areas autonomously.

On the other hand, the user is always free to withdraw from the system if ever he feels that he needs more privacy. All our users are adults and therefore have the right to decide to be left by themselves. The system will then stop the continuous monitoring. Nevertheless, the user's position can be obtained by the educators at any time, so that they can always find where the users are and reach them in case of need.

Fading of the scaffolding is then decided by the educators. Such fading can be complete for all the users that can move around town all by themselves, but it may also be kept in some form to support those users, or those areas, which are weaker and need a constant support. As an example, being on time is one ability that has to be managed in autonomous living: people have to reach their job by a certain time and cannot be late. People with DS tend to have problems in time management; therefore, it may be impossible for them to understand how long

it will take to reach their destination. Smart Angel can offer a valid help in these cases by suggesting the person that he may be late.

The Smart Angel system is therefore both a scaffolding tool in support of the user's learning and a distributed intelligence system, as defined by Pea [8], supporting the single users in the most difficult tasks.

### **3 CONCLUSIONS**

In this article, we have outlined the rationale behind the Smart Angel system and briefly described its main features. ICT and Cloud based technologies, along with localization services, have been used as scaffolding tools to contribute to supporting the learning process of intellectually impaired users.

For these kind of users, cognitive skills, short-term memory and reading writing abilities [19] are often not enough well-structured and thus cannot fully contribute to support learning. Furthermore, conceptualization and abstract concepts may be difficult to use. Our system allows the learner to act directly on the final task while receiving all the needed support. Educators manage the users' learning by defining how much and what kind of scaffolding is needed, letting it fade as the user's skills increase.

The Smart Angel approach, based on the newest technologies, is innovative and offers several advantages. Caregivers and educators can save money and time by relying on a distributed system that allows them to manage the learning activities without the need of a constant physical presence. They also reach a deeper knowledge of the users' abilities since they have much more information about their movements around town than they would otherwise have. This deeper knowledge is the base on which the scaffolding is designed and adapted to the single users on a daily basis. Furthermore, it will add up to the general knowhow about the process of learning independent mobility for our target users.

The target population is guaranteed a greater freedom that it would otherwise have thanks to the possibility to be constantly monitored and immediately supported when needed. Furthermore, safety is enhanced: they cannot get lost and they have the constant possibility to have immediate feedback about their being on the correct way and on time.

The Smart Angel project is still in progress and the experimental phase is currently carried on. The project outcomes are still being elaborated and will be discussed elsewhere.

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