

# NFC based provisioning of instructional videos to assist with instrumental activities of daily living

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**Abstract**— Existing assistive living and prompting based solutions have adopted a relatively complex approach to supporting individuals. These solutions have involved sensor based monitoring, activity recognition and assistance provisioning. Traditionally they have suffered from a number of issues rooted in scalability and performance levels associated with the activity recognition process. This paper introduces a simplistic approach to assistive living within a user's residence through the use of NFC tags and smart devices. The core concept of this approach is presented and is subsequently placed within the context of related work. A description of the architecture is provided and results following technical evaluation of the first system prototype are discussed.

## I. INTRODUCTION

The worldwide population is transitioning to never before recorded, uneven, composition resulting in global aging [1]. This global aging is expected to produce a situation where by 2050 over 20% of the population will be aged 65 or over [2]. This change in population is expected to produce an increase in aging related illnesses which, in turn, are expected to place additional burdens on healthcare provision and its associated support infrastructure [2]. Additionally, this aging within the population will be accompanied with a reduction of the ratio of working aged people (15-64) to those over 65, thus reducing the amount of informal support available [1].

The portion of the population suffering from these aging related illnesses will therefore require some form of support to live independently and remain within their own homes for as long as possible. Ambient Assistive Living (AAL) is a technological based approach which aims to support

individuals with aged related impairments [3], [4], [5]. AAL has been widely viewed as a promising approach to address the problems associated with aging and subsequently increase the independence of individuals [5], [6]. One of the core elements within the domain of AAL focuses on solutions with the intention of assisting individuals with successfully completing both Activities of Daily Living (ADLs) [7] and Instrumental Activities of Daily Living (IADLs) [8].

Although a number of solutions exist which provide support for ADLs/IADLs, these solutions each come with advantages and disadvantages. The Personal IADL Assistant (PIA) project aims to address some of these weaknesses by producing a cloud-based, social-network augmented approach. This approach removes the complexity of current approaches and provides a scalable method of flexibly providing reliable video-based instruction.

The PIA approach provides assistance with IADLs by providing video based instruction following interaction of smart devices (i.e. a phone or tablet) with Near Field Communication (NFC) tags affixed to household objects.

The remainder of this paper is organized as follows; an overview of related work is provided in Section II. The approach used in the PIA project is explained in Section III. Section IV details the results from the initial evaluation of the system and conclusions and future work are presented in Section V.

## II. RELATED WORK

A number of assistive systems currently exist to help individuals complete activities within a home environment. A large portion of these systems have been embedded within the Smart Homes (SH) paradigm with a number of approaches specifically offering prompting based support.

### A. Smart homes

SHs are residential environments which have been augmented with a variety of technologies in order to provide their assistive function. Generally, SHs incorporate three layers of technology to provide their function [4], [5], [6], [9], [10]. These layers include; a sensor deployment in order to monitor inhabitants, a processing layer to support some form of activity recognition or prediction and actuators to provide assistance. Actuators can be used to assist inhabitants with completing activities that they are having difficulty with. They can provide support in the form of automation within the environment itself or they can support interfaces which allow prompting in order to guide an inhabitant. The sensor components of SHs may employ a

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large number of sensing elements ranging from contact switches affixed to items to passive infrared and ultrasonic based tracking mechanisms to computer vision based solutions.

Generally, signals from these sensors are processed by some form of activity recognition or prediction process to determine the unfolding of activities being undertaken. Activities detected are subsequently monitored to determine if an inhabitant is having difficulty with their completion. If difficulty is determined an assistive prompt would be issued. After prompts are issued further observation and recognition processes may occur to ensure the activity has been successfully completed, if not additional guidance may be supplied [5], [6], [9], [10], [11], [12].

These assistive systems have shown promise; however, they have suffered from a number of barriers to their widespread adoption. Most notably, by requiring widespread sensor deployments and an associated processing layer to interpret unfolding activities. In order to deploy these systems in a preexisting residence, a potentially large sensor suite would be required. This retrofitting represents an inconvenience from the physical environment perspective in addition to incurring a financial cost making this process unfeasible for wide scale deployments [3], [4], [5], [6], [9].

Additionally, there are some limitations with current activity recognition processes including, lack of capability to flexibly model activities, difficulties handling interleaved and concurrent activities and privacy concerns [4], [5], [6], [9].

### B. Prompting systems

Prompting systems exist to provide guidance and reminders for their users given certain criteria. The prompts provided may be video, audio or text based. Of these types of prompt, video based instruction, particularly those with an audio component, provide a promising avenue to offer detailed and relatable guidance for users [5], [9], [10], [13], [14]. In particular, videos recorded by a trusted individual that a user may relate to can provide a sense of familiarity. This sense of familiarity is essential and provides important emotional contact with those who are providing care and also those who are receiving it [15].

One such system, COACH [10], was designed to support individuals suffering from moderate level dementia by assisting them with the complex hand washing ADL. This system uses a camera to monitor a user's hand washing activity. Images from this camera can then be translated into hand and towel positions by a tracking system. These positions are then passed to the activity recognition process with the aim of producing the current belief state. This belief state is associated with a policy that then determines how best to assist the user by prompting with relevant audio and video based instruction. The use of audio and video instruction within the study demonstrated promising results. Most notably the addition of the video component over previous non-video iterations showed improved results.

### C. The PIA Approach

In contrast to the existing approaches used in SHs, the PIA project offers a relatively simple paradigm to provide

assistance with ADL/IADLs. In PIA, the need for sensor deployment to detect activities is removed by instead relying on the use of relatively inexpensive NFC tags. The use of such tags allows a home to be outfitted for a small financial outlay. Similarly the complexity associated with using an activity recognition process is removed by instead requiring an inhabitant to manually request assistance by activating the NFC tag with a smart device at the time and place they require it.

A number of works have used NFC within the domain of healthcare [16], [17], [18], [19], however, none have dealt directly with providing assistance with ADLs/IADLs.

## III. THE PIA SOLUTION

Unlike approaches used by current prompting mechanisms, the use of easily recognizable NFC tags and smart devices allows the PIA solution to offer an easy to use and on demand approach to obtain assistance.

PIA is intended to provide support in a residential environment. With this approach there are two main categories of users; caregivers and users. Caregivers are typically friends, family or contracted assistance, however, may be any other trusted party.

Caregivers using the PIA system affix NFC tags to objects in a home (e.g. a washing machine). Then, using a smart device that has the PIA app installed, they record a video illustrating how to complete an activity associated with a specific NFC tag. After recording this instructional video the caregiver uploads the video clip to the PIA cloud and links the tag to the video via a reasoning system. The PIA app provides a simple interface and workflow for caregivers. This interface is shown in Figure 1.

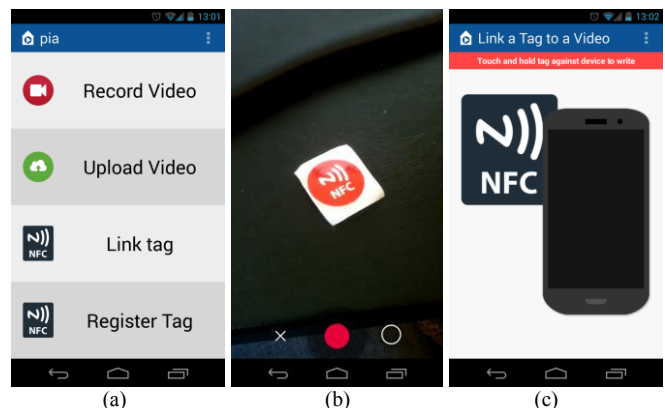


Figure 1. Screen shots of the menu (a), video recording (b) and tag linking (c) interface of the implemented PIA app.

Users in the PIA system are equipped with a smart device which has an instance of the same PIA app installed. If a user requires assistance they simply touch the smart device to an associated NFC tag, providing a simple avenue to gain assistance. The smart device interacts with the deployed NFC tag and reads its unique PIA ID. The ID is sent to the reasoning system to retrieve the URI of an associated video to download it from the cloud storage service and cache it on the device in order to automatically play it.

The combination of NFC tags, smart devices and a common app reflects the aim of PIA to provide a relatively

inexpensive and low complexity method of providing assistance.

PIA uses a number of cloud-based components. These components provide increased flexibility and functionality of the PIA system. The main components include the reasoning system and the video repository.

The implemented architecture of the PIA Project, as depicted in Figure 2, allows these cloud components to be changed and expanded upon as required.

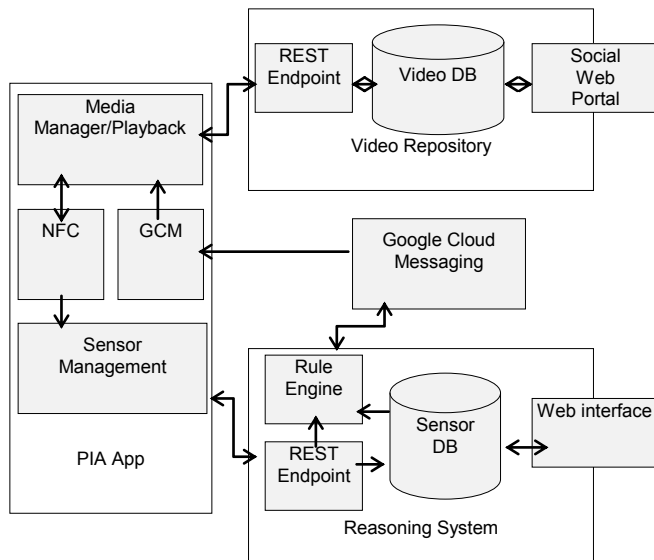


Figure 2. The architecture of the PIA project.

The reasoning component provides a rule based system for associating tags with videos. This reasoning system uses unique PIA IDs which are stored on deployed NFC tags in an environment and registered to its database.

When linking a tag using the app a default association rule is used to link the tag to a specific video allowing a low friction experience for the caregiver by not needing to explicitly create a rule. This allows a caregiver to assistance using only the PIA app.

On user interaction with an NFC tag its PIA ID is retrieved and sent to the reasoning service along with a Google Cloud Messaging (GCM) ID using web service communication for that particular device.

On receipt of the PIA ID and GCM ID the rule based reasoning system is used to determine the appropriate response to send to the smart device which provided the GCM ID. This response is sent to the device also using the GCM system. This response typically contains the URI of a video from the video repository.

Incorporating the reasoning system within the overall architecture provides a flexible mechanism of providing assistance based on rules allowing programmatic variation of a response for tag interactions. This flexibility can allow tailoring the instruction provided to a user depending on a number of factors such as the time of day or previous interaction with other tags in a residence.

In a scenario involving an NFC tag affixed to a coffee maker, for example, URIs of video instruction relevant to the time of day when the tag was activated can be delivered. For

example, in the morning a user may prefer an espresso coffee and in the evening a milk-based coffee may be preferable.

In addition, rules can be defined to provide alerts to specified persons when necessary. This can provide the facility for an alert to be sent to a caregiver if an anomalous behavior rule is encountered. For example, such a rule could be triggered if a user required repeated assistance with a medication task within a certain time frame, which could indicate difficulty administering medication or the possibility of an overdose occurring.

These rules can be modified and created using the web interface of the reasoning system.

The video repository provides cloud based video storage, media processing, a Content Delivery Network (CDN) and a social web portal. This component produces multiple versions of videos for the PIA system in order to provide formats that are suitable for a multitude of devices, screen sizes and connection bandwidths in order to provide a better user experience. The CDN allows scalable distribution of video, subsequently removing a potential bottleneck PIA cloud.

The social web portal provides the social network features of the PIA system. This social network provides caregivers membership of communities. Caregivers in a community may collaborate, share and comment on instructional videos. This allows caregivers to improve the quality of instruction and care that they provide to users.

#### IV. INITIAL FINDINGS

The PIA concept, along with a functional prototype of the PIA application deployed on a number of smart devices, was presented to focus groups. These focus groups were located in Germany, Norway and the UK and consisted of professional and family caregivers and older people (in the capacity of a proxy target user group). Some of the older people had memory problems and a small number had been diagnosed with dementia. A total of 41 individuals (11 caregivers, 30 service users) contributed to the findings of these focus groups.

These focus groups used presentations in conjunction with a variety of smart devices running the PIA app to demonstrate the concept in order to determine user and caregiver acceptance. Among the findings some of the most pertinent were identified as:

- the older persons and caregivers had a clear understanding of the overall aim of PIA and felt that it could be beneficial for persons suffering from memory problems, challenged by how to use new items around the home, or having difficulty maintaining their independence.

- the majority of caregivers believed that the PIA approach would be beneficial, however, not for those with advanced dementia. Instead, it was thought that it would be more useful for those with memory loss problems and early stage dementia. This belief is based on caregiver experience caring for individuals suffering from these types of problems. Specifically, difficulties can occur when technologies are used to assist users which are not familiar to, or compatible with, experiences that the user has had prior to the onset of the underlying memory problems.

Specific concerns raised related to the ability of the target users to recognize the unfamiliar NFC tags in their environment and then use these tags in tandem with a smart device in order to obtain assistance. These concerns may be addressed by printing custom, highly recognizable and PIA themed, NFC tags and by using a bracket and caddy combination to ease device alignment.

A further concern involved the potential distracting nature of using such a platform. It was reported that users might be distracted by using the system and following a video to the extent that they may be unable to concentrate on the task.

Additionally, concerns were raised about the suitability of such an approach for those suffering from diminished dexterity due to age-related conditions such as arthritis.

Finally, the focus groups listed use scenarios beyond the initially presented functionality highlighting the flexibility of the systems approach. These included the use of the PIA solution as a potential medication reminder platform and providing a mechanism for activities such as maintaining diet and grocery shopping.

## V. CONCLUSIONS AND FUTURE WORK

Using this approach the PIA project aims to offer an avenue of providing assistance with the activities of daily living thus providing greater independence. Furthermore, this assistance is offered via video based guidance from a familiar or trusted individual.

Unlike other solutions, which are reliant on complex sensor deployments within an environment, PIA uses NFC tags. NFC tags are inexpensive and are easy to affix to items in a home. This allows a relatively simple infrastructure for providing on-demand assistance with ADLs/IADLs. In addition, this approach does not require any complex activity recognition mechanism to function. Instead, it provides a support system that is suitable for useful and widespread deployment in its current form. Usability concerns are raised where users need to be aware of how to use the NFC tags and smart devices and how to align them with little margin for error.

Focus groups evaluated the PIA approach and have highlighted that it shows promise in assisting with IADLs for specific target groups where the user has the ability to use this technological solution.

Future versions of the PIA project will incorporate an increased amount of web based tools, including a refined version of the social network, and analysis tools. These analysis tools will cover IADL analysis and caregiver stress analysis which can be used as a quality of life metric for both caregivers and users. Finally, feedback from focus groups will be incorporated into future iterations of the PIA system.

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