

Evolving Framework for Building Companionship Among Human and Assistive Systems

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Abstract. The recent progress in artificial intelligence is allowing assistive systems like the voice-based assistant, virtual agents to become more personalized and adaptable. The role of these systems is also shifting from being a mere assistant to a personal companion. However ‘personal companionship’ being a subjective term lies open to interpretation, thus posing a challenge for the creators of these assistive systems. This study is an attempt to address this challenge with a user-centric approach. Based on insights gathered from an activity based method called forced photo elicitation techniques with 25 users, we evolved Human Machine Companionship Framework, as a reference tool for designing effective personalized connections between assistive systems and its user. We describe each of the essential behavioural traits that a companion should exhibit and their evolution with time and information gained. Lastly, we establish the use of this companionship framework by discussing its application in case of the social robots.

Keywords: Companionship · Personalization · Elicitation techniques · Assistive systems · Human-Human interaction · Human-Computer interaction

1 Introduction

Be it a personal computer, smartphones, voice-based personal assistants, virtual agents/companion, robots etc., there is a continuous focus on these systems to be perceived more human-like and natural. These systems have become a part of our daily lives by assisting in numerous activities, making our lives much easier. With recent shifts in the design of such smart technical systems, these are now being looked at, not only from a utilitarian perspective but also in the social and emotional contexts. The attention of Human-Computer Interaction (HCI) community is rapidly growing towards the adaptation of these systems based on the user’s needs, habits and mental abilities, and a continuous focus is on ensuring that they are perceived, accepted and utilised by their users as personal and empathetic assistants. Hence, we see an overall shift of technological devices from being considered as mere assistants to behave like the companion systems (CS).

In future, these systems will be our artificial companion [1, 2], behaving more like our personal and empathetic assistants and could be complementing the social roles and

needs of our partners, friends, caretakers etc. With recent advances in artificial intelligence (AI) in terms of emotional recognition, natural language and speech processing, it would be possible for these systems to understand our affective states, behaviour, desires, aspirations, personal goals effectively and behave accordingly.

Many studies, especially in the area of Human-Robot Interaction (HRI), have set the development of personal companion as a goal [4–6]. Research has also been conducted to understand the effect of various behavioural traits like empathy [7] social presence [8] in building a human robot companionship. The results of these studies suggest the need for incorporating social sense, emotion and traits of companionship in these cognitive technical systems. Past studies [3, 9] have even shown the relevance of similar emotions in the context of Human-Human Interaction being applied to Human Machine Interaction (HMI) for future companion systems.

Reeves and Nass [10] demonstrated with several experiments that users are naturally biased to ascribe certain personality traits to machines, to PCs, and other types of media. Therefore, it is important to understand how these perceptions of personality influence the interaction and how a coherent personality can be utilised for such technical systems. Further, for a designer and developer of these companion systems, it is important to have directions or framework on how to proceed in designing a personality of these systems.

However, a little effort has been there in understanding the overall process of building a long term companionship among humans and the technical systems. We try to overcome this gap by understanding the meaning of companion and companionship from the human-human interaction point of view, using an activity based exploratory user centred approach called forced photo elicitation technique. Some of the questions we try to address are –

- What are the different expectations or perceptions that people have around the whole notion of companionship?
- What kind of behavioural patterns or traits do people look for in their companions? What is the role of time in terms of building companionship?
- Whom do people consider or relate to as their companions?

In this paper, we have explored the possible answers to these questions by evolving a time and information based Companionship Framework. We describe the Companionship Framework by first discussing the different characteristics of companionship. Then we describe the essential behavioural traits that are required for the building of companionship. Further, we try to explain the expression of each of these traits with time and how each of these develops with an increase in the amount of information and time.

Lastly, inspired by our user-centric understanding of human-human companionship we discuss the application of this Companionship Framework in the context of human-robot companionship.

2 User Study

2.1 Forced Photo Elicitation Technique

The research questions under exploration in this study being abstract in nature and the definition of ‘Companionship’ itself being very subjective, conventional user-centered design methods were not applicable. We used an activity-based user-centered approach called Forced Photo Elicitation technique [11], which is found suitable for such studies. In this activity, around 120 random samples of photos with abstract content were printed and were displayed to a participant. A total of 25 participants were involved in this study evenly distributed across various age groups and the two genders. Participants were asked to carefully scan through all of those photos, and then were asked the question, ‘what is a companion for you?’ They were asked to pick minimum five images in prioritized order as their response to the question (Fig. 1). They were then probed to explain their interpretation of each abstract image and how they associated the content of the image with the word ‘companion’. Further probing questions were asked during this session to elicit numerous user stories.



Fig. 1. User performing photo elicitation technique

2.2 Research Analysis

All the interactive user sessions were audio recorded and transcribed. The data was then analyzed using grounded theory approach, which included “affinity clusters” of newly generated themes and categories. In the first level analysis of raw user data, numerous behavior *traits* coupled with different *companionship attributes* emerged. These were then regrouped to generate *mega-categories and hierarchy of themes*. Themes were

chosen by putting all post-it notes (containing observations and respondents' quotes) together, and then arranging them in piles, in terms of those notes that went together. Each pile or cluster was given a name, according to what best described all the items and contents under it [14].

In order to understand the relationship and connections between the *traits* and *mega-categories* they were analyzed using *Consensus Mapping* technique [12, 13]. In this technique all the identified *mega-categories* were written along with all the associated *traits* for each of the *mega-category* written below them. It was observed that these *mega categories* displayed a hierarchical pattern with incremental progression, i.e. each trait was seen to be supporting the next trait. For instance, *familiarity* as a trait was found to get developed and matured into healthy *curiosity*. At last significant *traits* with greater impact were demarcated leading to the establishment of the hierarchical relationship and the Companionship Framework.

3 Human Companionship Framework

In our research, we considered 'Companionship' to be a connection established between two or more entities that are similar or diverse in nature. Human is always considered to be one among the two entities. Thus, there could be companionship among human-to-human, human-to-another being like the pet or human to an object such as book, music etc. Our study indicated that irrespective of the entities involved, the evolution of companionship may follow a similar high-level progressive path, which became the basic assumption for our proposed Companionship Framework. For the people of HCI community, such framework can be a reference to understand how companionship may develop over time between the involved entities and then create design interventions to support this if one of the entities is an intelligent agent. To cognize the companionship framework it is imperative to know the distinct characteristics of companionship which forms the foundation of such framework, the building blocks and meta-categories involved which bind the numerous behavior traits together and the evolution of these traits based on the amount of information gained and time spent.

3.1 Characteristics of Companionship

In our study, we identified various characteristics of companionship that were re-grouped together to form the four prominent themes: power and control, amplified emotions, sensory immersion and attachment.

There is an equation of power and control seen between the two entities involved in companionship. The equation may be balanced, but there inevitably occurs a tug and pull of power and control between the two entities. Based on the power and control dynamics seen between the two, these two entities were termed as a 'Reacher' and a 'Settler'. Reacher refers to an entity who is reaching for somebody of the higher power, whereas, Settler is the other entity who settles with somebody of lesser power. The equation of Reacher and Settler is very important in building a companionship which would be seen throughout our framework.

Similarly, through our user data, we inferred that whenever a person experiences amplified emotions such as joy, fear, anger, etc., they are inclined to have their companion(s) experience/express emotions alongside them. The expressed emotions would be dependent on the entities existing mental and emotional state, their interpersonal relationships etc.

When companionship matures, there is a certain sensory immersion observed between the entities, where each of them connects by sensorial intimation like touch, smell or visual and become extremely aware of each other presence.

As strong connection begins to develop between the two companions, the attachment becomes stronger. This could lead to the building of trust and a sense of protection between the entities, where the Reacher seeks for protection from the Settler and Settler is the protection provider.

3.2 Companionship Progression and Building Blocks

We identified four major Building Blocks of companionship: ‘Compatibility’,

‘Presence’, ‘Trust’, ‘Connect’ that binds the numerous behavioral traits. The foundation of companionship starts with establishing compatibility among the companions (Fig. 2). As the entities mature from one trait to another and move in a progressive wavelike pattern, it traverses from compatibility to experiencing a sense of presence to the building of trust and ultimately the formation of strong connects among the companions. This progression is strongly dependent on the level of interaction and time spent together. Drawing an analogy with the human process of ageing, as the entity crosses each stage it retains the compound information gathered in the previous stages and levels. In case a behavior trait is skipped or given insufficient time to develop, the

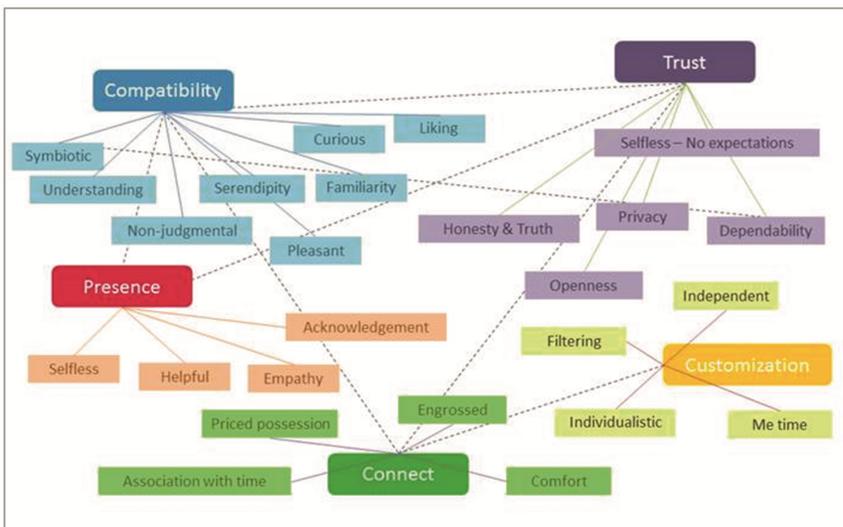


Fig. 2. Consensus mapping for interrelationship among traits

companionship bond may break and a difference of opinion among entities may occur as each level builds on its preceding levels.

3.3 Evolution of Behavioural Traits

The behavioral traits are explained, as factors of the four primary characteristics, i.e. the Reacher-Settler, Amplified emotions, Sensory immersion and Attachment. Figure 3 shows the hierarchical progression of companionship framework. It is a graphical representation of the amount of time the involved entities have spent together to the amount of information gathered about each other.

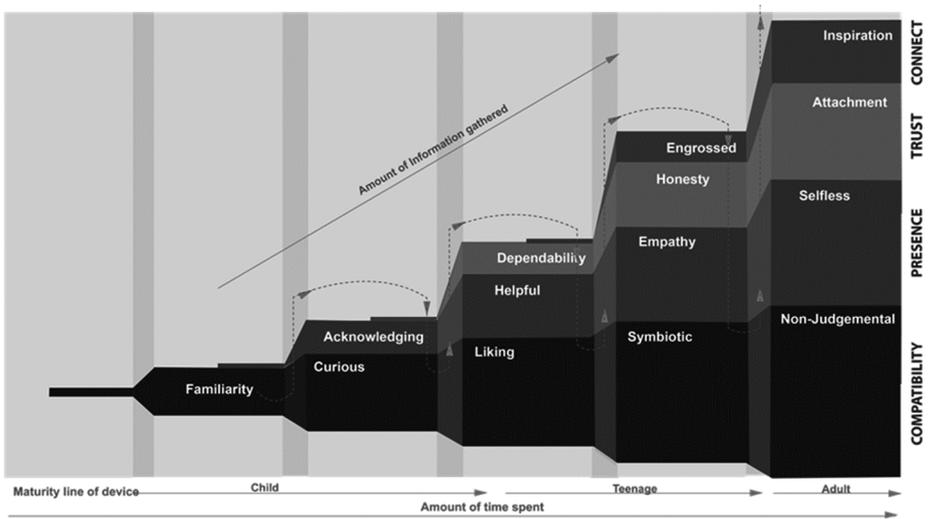


Fig. 3. The hierarchical framework for building companionship

Familiarity in the context of companionship means allowing each other to be their natural self. At this stage of the relationship, both the entities try to find a similar sense of purpose within each other. Similarities could be in terms of interests, likes or dislikes, beliefs, attitude, etc.

In the *curiosity* phase, the entities learn about one another, by noticing or observing actions, language, etc. The learning doesn't mean mimicking, but it's about knowing each other to make the familiarity quotient stronger. Humor is also added to shift the dynamics from formal to casual. Simultaneously, *acknowledgement* makes the presence felt through any noticeable action like gesture, body language, smell, etc. which signifies physical presence. In this phase the casual behavior becomes more pronounced and the companionship becomes stronger owing to each other's' presence. A state of ease is established between companions alongside a degree of acceptance as seen through *fondness* and *liking*. The sensory immersion is also seen, where the Reacher and the Settler recognize each other through their sensory stimuli (like touch, smell, etc.).

Helping or providing assistance to your companion is also an important trait. This help is perceived to be selfless in nature and it is more about increasing the sense of protection. In this case, one entity feels that the other entity is there whenever required, for any support. A sense of *attachment* and *trust* begins to develop at this stage. The Reacher knows the Settler to a certain extent and the Settler starts trusting the Reacher. The Settler becomes dependable on the Reacher for certain tasks and provides a degree of access or autonomy to take certain decisions. The autonomy leads the equation of power and control between the Reacher and the Settler to mature on equal terms. This is the start of the *symbiotic* stage, where the relationship develops in a way that mutual interests grow. The two entities also tend to understand each other much better and empathetic behavior is seen. Here presence is very important. Companions look for each other when their emotions are amplified (happiness, anger, etc.), so the warmth should be felt and they should be accommodating and supportive of each other. With increased level of understanding, the trust level also becomes stronger and a level of honesty is seen among companions. Though honesty doesn't mean always being direct/straight forward and a certain degree of diplomacy is necessary. Honesty also refers to respecting the 'others' privacy and the ability to sometimes forget few secrets as well. The relationship also acquires a sense of timelessness and the entities become totally engrossed in one another. The connection between the entities reaches a stage of transparency. As companionship matures over time, a lot of information is being gathered about each other. This gathered information may lead to assumptions or opinions about the other person's beliefs. However, companions shall remain non-judgmental and should not disrespect other person's belief in any situation.

In final stage power equation between Settler and Reacher is reversed, the Reacher is now the Settler and vice versa. This leads to the *selfless* state, where appreciation is exchanged to increase trust; one of the entities becomes a form of motivation to the other. He places the other entity desires first and thinks of self-next. A blind trust is created. This blind trust creates a strong sense of protection between entities which leads to attachment among them. Finally, the bonding among the companions is at its pinnacle. They become an inspiration to each other and start setting higher goals. This healthy competition keeps them growing and *connected*.

3.4 Social Roles

During our discussions, most of the participants associated companion with various social roles in their lives. We did the frequency mapping of all the social roles and compared it with the categories in our framework. The most prominent roles appeared to be a friend, spouse, siblings, parents, pets, book, music and nature. Spouse as a social role was mostly spoken about.

4 Application of Framework

The proposed Companionship Framework can be applied to various situations that involve companionship relation. In this section, we demonstrate the use of this

framework in designing the behavior, interactions and encounters of a social robot with its user. Once the robot is brought and introduced to the family and home scenario, it is programmed to do assistive tasks and behave like an assistant. At this point, in the framework of companionship, it is at the initial stage and on the maturity line of devices, it is at the start, like an infant who is new to the world. Referring to the Settler and Reacher characteristics between companions, it becomes inevitable that the robot is always the Reacher since humans would like to play the role of the controller and the Settler.

In the first stage of the framework, the robot and the user start to establish familiarity between them, by getting to understand each other. Once the familiarity is established, the robot matures to curiosity about various subjects around it. The robot begins to pose subtle questions to the user such as, 'how was your day?' This signifies the start of casual behavior with the user. This casual behavior will also induce a friendly atmosphere around the existence of the robot which could be strengthened through the little use of humor. The acknowledgement develops alongside curiosity, where the robot begins to make its presence felt. As the robot get to know each member of the house, it starts performing simple actions like waking them up every morning, greeting them with a gesture of a smile, etc. These small gestures and questioning mature the companion traits in the robot and a personalized behavior is established with each and every member of the house. When the first three behavior traits are strengthened gradually, a sense of liking is developed towards the robot. The robot is being started to be perceived as a family member, who is able to process certain feelings of the other family members. For example 'I like the dress you are wearing, you look beautiful'. In the previous four stages, the robot is learning and growing up like a child, developing curiosity and a sense of understanding about the environment. With all the information gathered and the time spent to reach the 'liking' stage, a change could be observed in robot's behavior from extremely formal to largely casual and personalized according to the user.

In the next stage, the robot is matured and entered into the teenage stage. It has become helpful, and other than the assistive task it is able to detect problems and provide suggestions to the user, like 'the gas is about to get over, get it refilled'. Here the trust towards the robots has started to develop. This trust is built to such a level, that the robot now has a certain level of autonomy, making way for the dependability stage. In this stage, the robot exercises a degree of freedom to take decisions on the user's behalf. For instance, the robot gets the leaking pipe fixed without asking the user; thereby helping the user in easing the task. This is where both Reacher (robot) and Settler (user) starts to meet on equal terms; the power and control will come to equilibrium, which will be seen in the stage of symbiosis, empathy and honesty. Gradually the robot gets even more autonomous and casual with the user. The robot understands the user's emotional value and becomes more empathetic to situations. It is desired to see the robot mature up to this level. In the stage of non-judgment, self-lessness, attachment and comfort, the table reverses; the Reacher becomes Settler and Settler – the Reacher. It is seen that with more information and time, the robot may have higher control, like a mature adult, understanding the situation and comforting the user.

This storyline is a scenario created to explain the framework, which may differ based on the assumption of the framework. Similarly, this framework can be applied to other applications like conversational agents, voice assistant and mechanical robots as well.

5 Conclusion and Future Work

Our understanding of ‘companionship’ based on user insights led us to evolve the proposed Hierarchical Companionship Framework. The main applicability of this framework is, as a guideline and a reference for designers and solution developers of intelligent agent systems to systematically define the personality and behavior to transform such systems towards being companion to its end users. We have applied this framework to create several design solutions for a social robot product with an objective of making the product as a user’s companion. In further research, we would be evolving the proposed framework to be more concrete reference tool for designing various companionship based products. As part of the next step in our research we have already applied this framework in case of designing a personality for voice based applications.

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