Syntactic/Semantic Formalizations and Metrics of Residential Applications Based on Gestural Interface

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Abstract. The development of residential applications with gestural interaction focuses often only on technological and physical aspects in the construction of its applications. The use of technologies that support gestural recognition might restrict the gestural commands of an application. We argue that an abstraction of gestural interaction is required for a more comprehensive interaction approach. In an attempt to reduce problems related to gestural interaction, in this work, we formalized gestural interaction syntactically and semantically. The syntactic formalization uses building blocks that produce a grammar of the Extended Backus-Naur Form (EBNF) type. The semantic information is described by the point of view of residential application, together with their actions or services offered in the application. Additionally, we analyze the relations and combinations of gestural interaction syntactically formalized in generating a set of metrics for evaluating qualities of interaction that are based on recommendations for residential systems, in which the entire description comes from the pre-established syntactic formalization.

Keywords: gestural interaction, domotics, organizational semiotics, EBNF, smart home, home automation.

1 Introduction

The use of gestures is an emerging approach to interaction with residential systems. In a previous work [4], we described several solutions that take advantage of this type of interaction, with or without using physical artifacts such as wands (e.g. [13,16]), rings (e.g. [12]), or remote controls. With the emergence of hardware able to recognize a predefined set of gestures such as “horizontal”, “vertical” or “depth”, developers can speed up the development process.

Residential interactive systems generally require solutions that provide a wide variety of services to the residents some of which still might have an innovative character for them. Thus, the design of these solutions should consider factors that support constructing the gestural vocabulary of their applications. Without an

abstraction of implementation details of gesture recognition, a large workload is imposed to the programmer [8]. In an attempt to reduce this problem, to devise a formalization of gestural interaction shows up to be evident [1,5,6,8,9,10,14,15], as we also realize the need to analyze what are the consequences of the gestural vocabulary imposed to the users [4]. For this, the semiotic foundation to involve syntactic, semantic and pragmatic layers on the linguistic form in question is necessary.

In this context, this paper proposes an abstraction of the gestural vocabulary in the form of building blocks that aim to support developers in defining gestures with desired properties, and that also might assist in users' customization of gestures. The two sides – i.e. developers and users – can communicate through a uniform description for different types of gestures that might be used. Specifically, we discuss the syntactic and semantic layers the formalization.

First, the syntactic information of gestural interaction are worked through the specification of a grammar of Extended Backus-Naur Form (EBNF) type [8]. We then discuss semantic information of gesture usage that is described by instantiating the grammar for a residential application, together with their actions or services offered by the application. Subsequently, we analyze the combinations and relations of the micro-gestures¹ derived from the syntactic grammar, generating a set of metrics based on recommendations for residential systems [3], in which the whole description of the movements used to interact is described in predetermined syntactic formalization.

The paper is organized as follows: Section 2 presents related work; Section 3 presents syntactic and semantic formalizations; Section 4 presents the metrics; Section 5 discusses the proposed formalization and metrics; and Section 6 exhibits the conclusion.

2 Related Work

The search for a standardization of gestural properties used to interact with applications motivated many researchers to immerse themselves in research to this end; presenting solutions that provides subsidies for applications of interaction by area or by the whole body, in perceptual form through Microsoft Kinect2, Play Station (PS) Motion3 or just using cameras.

Spano et al. [15] reported the importance of a temporal analysis of gestural interaction, since multi-touch interface notifications are only transmitted after the full detection of the gestural command. The authors structure gestural interaction in a compositional and declarative way through meta-models based on Petri Nets⁴, mentioning support for whole body gestures. Their approach is achieved by building

¹ Correspond to smaller syntactic descriptions of gestures.

² <http://www.microsoft.com/en-us/kinectforwindows/>.

³ <http://us.playstation.com/ps3/playstation-move/>.

⁴ A Petri net is a bipartite graph consisting of two types of nodes – i.e. places and transitions – which are connected by directed arcs [15].

blocks. More complex gestures are formed by combinations of simpler construction blocks and the behavior of the User Interface (UI) may be associated with the entire gesture recognition or any other subcomponent, addressing the problem of granularity⁵ for notification events.

Doherty et al. [6] show how formal modeling can be used in designing a dynamic gestural language defined by sequences of poses. These authors discuss models at different levels of abstraction to deal with usability issues, such as ambiguity and overlap in gesture recognition. The application object of analysis in this paper allows the definition of a language of gesture in an initialization phase separated from the real gesture recognition. At this stage, the user “shows” the system different poses that appear in the command. The characteristics of the individual postures are captured and stored. Subsequently, the poses captured may consist in sequences, each one defining a gesture. After this initialization the application is ready for gestural interaction using the defined language. The typical characteristics which are used to characterize the positions are the hand orientation and the values of bending joints of the fingers. For some dynamic poses, the trajectory of motion is also specified.

GestIT [14] and Proton++ [9,10] present a declarative and compositional framework of gestural interaction. Proton++ allows developers to declaratively describe the custom gestures separating the temporal sequence of events from the code associated with the UI behavior, representing them as regular expressions. In GestIT custom gestures are defined by an expression, from a set of basic conditions which can be composed by a set of operators, for defining temporal relations in task modeling. One of the explicit concerns in both studies is the need for an intermediary feedback while performing the gesture to the application. Both approaches are directly related to events and the development of gestural interfaces. However, their representation with respect to the execution of the gesture by the user does not include position, angles and directions information.

GeForMT (Gesture Formalization for Multi-touch) [8] uses an EBNF grammar for describing the syntactic form of multi-touch gestures. Thus, the paper aims to formalize the multi-touch gestural language based on semiotics. Although the syntactic, semantic and pragmatic dimensions are mentioned in the research, its main focus is in the description of the symbols and their combinations that permeate the syntactic study of multi-touch gestural interaction; producing a two-dimensional approach to the grammar developed in this study. Basic gestures of multi-touch interaction can be described by GeForMT in a general and understandable way, through the use of functions, operations and atomic units of composition that are easy to memorize. By identifying the similarities of touch sensitive and point interactions, Kammer et al. [8] extend their approach to a three-dimensional representation that combines both interactions, i.e. multi-touch and point.

⁵ Granularity is a partial recognition of the interaction that enables notifications during the process of interaction [15].

Concerns about standardization of gestural interaction and some of its problems become evident. Although some studies mention that the approach is by whole body, neither of these works depicts gestural interaction beyond the use of hands. We are also seeking for more detailed descriptions on the execution of performed gestures, mainly with the vision of the conception of gestural interaction for the user [4]. Thus, with a more descriptive formalization we aim to obtain more subsidies to describe metrics from this syntactic formalization.

Of all the works, semantics is explicit only in the approach of Kammer et al. [8] by exposing a set of researchers who use classifications to human gestures; without a clear association of gestural interaction used in the application to the semantics of the gestures. Spano et al. [15] through Petri Nets that binds the application interface, but it is difficult to understand for an effective use in developing applications.

3 Formalizations

In the following subsections, we describe the syntactic formalization of gestural interaction and the semantic formalization of the interaction. Subsequently, we present examples of both approaches.

3.1 Syntactic Formalization

According to Liu [11] we can define a syntax based on Organizational Semiotics (OS) using names of syntactic categories and production rules. In this case the syntactic form is concerned with the rules of composition of complex signs from the simpler ones. For a formal language, Liu [11] mentions that the rules for the generation and analysis of formal expressions allow us to measure the complexity of a single method and a system of signs. An important reason for the study of syntax is to provide a clear and structured window of the human mind over the gestural language in question.

So to describe gestural interaction as a set of blocks for syntactic formalization, we developed a dismemberment of gestural interaction as **movements** which are derived from gestures or micro-gestures. This gestures can be **static** or **dynamic**, these being specified as a **function** that designates which part of the body is required to gesture and its action. For the static gestures its corresponding action is to **maintain** the function in a given direction or at an **angle** relative to a function of the body for a **minimum** and/or **maximum time**. Dynamic gestures have the **move** action. The execution of the gesture may be in **linear** or **circular** direction. In the linear direction you can determine a direction and a displacement. In the circular direction it is possible to determine the **rotation** in degrees, the **axis** of rotation and direction, i.e. **clockwise** or **counter-clockwise**.

These movements can be combined of several micro-gestures, being them executed in **parallel** (*), **composition** (+) or in **sequence** (.) (Fig. 1a). Furthermore, as the

gestural interaction is complex, we can enforce relationships between various movements such as **cross**, **join** and **separate**, (Fig. 1b), we can also make combinations between these movements and their relationships (Fig. 1c). Fig. 1 is a representation of the elements used in syntactic formalization to aid the understanding of the dismemberment of gestural interaction.

Fig. 1. Gestural language structure for residential applications

To better understand the grammar proposal is valid to mention that the EBNF grammar is defined as an ordered sequence of rules. Each rule contains a left and right side separated by a symbol formed of a colon followed by an equal sign (“::=”). Forms of right-hand control may include: (a) a sequence given from left to right; (b) choice, represented by the character pipeline (“|”); (c) option, square brackets (“[]”) allow to include optional items between the square brackets; and (d) repetition, brackets (“{ }”) allow to include items repeated zero or more times, between brackets.

For the construction of a representative grammar of three-dimensional gestures to control residential applications that prioritizes upper body movements, Table 1 presents the results of the formalization.

Table 1. Syntactic formalization of gestural interaction

<gestural_interaction>	::=	<movement> <relation>[<movement>{,<movement>}] <gestural_interaction><combination>[[<gestural_interaction>[]]
<movement>	::=	<gesture>{<combination><gesture>}
<gesture>	::=	<static> <dynamic>
<static>	::=	MAINTAIN (<function>,<direction>[,<time>]) MAINTAIN (<function>,<angle><function>[,<time>])
<function>	::=	<finger> <hand> <arm> <forearm> <head> <thorax>
<finger>	::=	<hand>[FINGER ((1-5){,(1-5)})]
<hand>	::=	HAND_(RIGHT LEFT)
<arm>	::=	ARM_(RIGHT LEFT)
<forearm>	::=	FOREARM_(RIGHT LEFT)
<dynamic>	::=	MOVE (<function>,<linear> <circular>[,<time>])
<linear>	::=	LINE <direction>[,<displacement>]
<circular>	::=	CIRCLE <rotation>
<direction>	::=	N NE E SE S SW W NW FRONT BACK N-F NE-F E-F SE-F S-F SW-F W-F NW-F N-B NE-B L-B SE-B S-B SW-B W-B NW-B
<time>	::=	(MAX MIN) (1-9){0-9}s MAX (1-9){0-9}s, MIN (1-9){0-9}s
<angle>	::=	(0-9){0-9}°<axis>
<rotation>	::=	<angle>(CLOCKWISE COUNTERCLOCKWISE)
<axis>	::=	x y z
<combination>	::=	* + ,
<relation>	::=	CROSS JOIN SEPARATE
<displacement>	::=	(0-9){0-9}cm
<position>	::=	<function>(TO RIGHT, TO LEFT, UP, DOWN, AHEAD, BEHIND)[<displacement>] OF <function>

Besides the detailed description of gestural interaction, it is perceived that formalization abstracts any technological evidence involved in the interaction and UI. In the next subsection we illustrate the syntax of the interaction in an example with the semantic description.

3.2 Semantic Formalization of the Application

The Semantic mentioned in Organizational Semiotics [11] is given as meaning or semantics of a sign, usually considered as a relationship between a referred sign. Under this definition of meaning, there must be a “reality” assumed, so that the signs can be mapped to objects in “reality”.

From previous studies of residential applications we extracted a set of basic functionalities ideally required for such applications, as services, for example, to open

the door and turn on the lamp. The semantic description of gestural interaction relates to changes in the environment that the application works through the features, available to the user, which are executed through gestural commands.

Idealizing a residential application, the features observed to be the most important are: available services for the user to interact directly with objects/elements of the house such as door, lamp, window, fan; and offer scenarios that allow users to modify the home environment, as previously defined scenarios which can modify multiple objects/elements of the house through the same control as, for example, prepare the environment for watching a movie.

Thus, to represent the semantics of this application, Fig. 2 shows basic elements detailing the application. As mentioned, a basic application for residential environments must provide their features (Fig. 2a), present interaction commands (Fig. 2b) that will be externalized to changes in the environment (Fig. 2c) and in the respective feedbacks (Fig. 2d).

Fig. 2. Basic semantics structure of the residential applications

For a better understanding of the importance of this formalization to residential applications, in Fig. 3 we exemplify its use.

Fig. 3. Example of semantics and syntactic structures to the "open the door" service

The semantic formalization of the application is crucial for the definition of gestures. Through all of the features of the application, containing the details of what will happen in the residential environment, designers will be helped to choose which gestural command better suits the context; since there will be an association of the application and the use environment with the design of the gesture. This will allow designers to predict the gestures for their applications, idealizing and better suiting the gestural commands to the context in which they are submitted before they even implement the application. It is also possible to check the application complexity and better analyze the aspects of gestural interaction based on [3].

4 Metrics

Correia et al. [3] mention a number of key recommendations for residential interactive systems that use gestural interaction. The set of recommendations is classified according to physical, perceptual and cognitive abilities. Some of these recommendations have been mapped in metrics based on the syntactic formalization details.

GQM [2] will be used, a general purpose approach composed of three levels, i.e. goal, question and metric. Being an adaptive approach, the various environments and organizations make use. Thus, as Hussain and Kutar [7] we extend the use of the approach for larger prospects, being allowed to apply in some recommendations for residential interactive systems [3]; configuring the recommendations (F)lexibility, (B)alance, e(X)plosion, (C)oordination, (T)ension, (R)esistance and (E)ffort, now in goals of the GQM approach.

From these objectives, several questions can be formulated, then a series of metrics is chosen to answer them. According to Basili et al. [2], the same metric can be used to answer different questions; in the same way, metrics and questions may be used in several GQM models for different purposes. It should be noted that the metrics are based on the syntactic formalization described in previous section. Table 2 and Table 3 represent the result of GQM approach to gestural interaction. Table 2 lists 19 metrics that are used for mapping with the questions and goals presented in Table 3.

Table 2. Metrics list based on the syntactic formalization

M1. Variation in body axis	M11. Angle between body parts
M2. Variation of position	M12. Rotation
M3. Variation of direction	M13. Opposite rotations
M4. Direction	M14. Distinct movements
M5. Position	M15. Displacement
M6. Number of combinations of static and dynamic gestures	M16. Duration of a static gesture
M7. Number of combinations of relationships	M17. Maximum execution time
M8. Number of combinations	M18. Minimum execution time
M9. Number of relations	M19. Parallel execution
M10. Number of body parts	

The questions that are associated with flexibility are characterized by concern to require the user a high degree of movement of the joints or strong curvature of the body parts; about the need to keep a part of the body very flexed or too extended while performing the gesture command; and also if there is a displacement, a sudden change of direction of movement or if the gestural command requires the user to stoop. Through syntactic formalization of gestural commands that comprise the vocabulary of the application, it is possible to check these aspects of flexibility through the angles between body parts, different positions and direction, displacements and rotation of the movement that characterize its metrics.

Table 3. GQM Approach

Goals	Question	Metrics
F	Does the gesture require a strong curvature of the body parts?	M5, M11 & M12
F	Is there a large displacement of a body part?	M2, M3, M4, M12 & M15
F	Is there a sudden change of direction of a body part?	M3 & M12
B	Is there an intense rotation of the body?	M11, M12 & M13
B	Is there an intense change in the inclination of the body?	M1, M3, M11 & M12
X	Do the gestures have abrupt changes in motion?	M6, M7 & M13
X	Are the gestures fast?	M11, M15, M17 & M18
C	Are there many parts of the body involved in gestural command?	M10
C	Are there distinct movements being performed by various parts of the body simultaneously?	M10, M14 & M19
C	Are there movements of more than a body part being performed in parallel?	M10 & M19
C	Does the user need to rotate sequentially clockwise and anti-clockwise?	M13 & M19
R	Do members need to be elevated several times?	M4, M5, M8 & M11
E	Is the gesture very elaborate?	M7, M8, M9 & M10
E	Does the gesture require the user to move a body part?	M1, M2, M12 & M15
E	Could the gesture be performed lying down or sitting?	M1
F & B	Does the user need to stoop?	M1, M2, M4, M11 & M12
F & T	Does the gesture require the user to maintain a body part much flexed?	M11 & M12
F & T	Does the gesture require the user to maintain a body part very extended?	M11 & M12
B & X	Is there a sudden change in direction of the body?	M1, M3 & M12
B & T	Does the gesture requires to position a body part out of the relaxed position?	M1, M2, M3, & M11
B & T	Do members need to be elevated?	M4, M5 & M11
B & R	Is the gesture long?	M16, M17 & M18
T & R	Does the user need to strike a pose for a long time?	M16 & M18

The questions related to balance are intended to verify gestures that may cause imbalance to the user. An intense rotation or a sudden change in direction of the body, body inclination and need of the user to stoop, show evidence that gestures may cause imbalance to the user.

The sudden changes of direction in any part of the body, such as moving the hand from north to south, or whether there is a variation of movements – a variation of static and dynamic gestures in a given time period will result in natural acceleration of user movement. Under these conditions the command will require the user an explosion to execute the command.

By involving various body parts on the gesture and assigning difficulties of doing different movements between these parts, the degree of difficulty increases for users who have little coordination. For example, rotate the right hand clockwise and the left hand counterclockwise. Likewise the movements being executed in parallel by several body parts.

Flex or extend the arm too much, elevate body parts, make a pose for a long time, tense the muscles of users. Commands that are executed in a period of time should be analyzed by the resistance of potential users. Besides gestures of elevation that takes the user from the comfort zone, i.e. raise the arms above the head for a certain time, especially when they are performed repeatedly. The main gestures should observe these requirements.

Commands that require a greater degree of effort from the users are those more elaborate, with several sequences of steps to termination, also characterized by excessive time, changes in the user position, perform commands standing and sitting.

5 Discussion

Technological advances stimulate the development of more natural interactions for residential applications, mostly by referencing a context of intimate and familiar use. Seen this need, a form of interaction that begins to be explored further in this field is the use of gestural interfaces, being a kind of communication already used naturally in this environment.

But the choice of gestural interaction also brings many challenges of development that go beyond the difficulties of gesture recognition. The unrepresentative choice of gestural commands to the context, the lack of concern with the diversity of users, lack of standardization of controls, the little detailed description of the commands used are some problems that are not directly associated with the application technology.

So, with a syntactic formalization of gestural interaction, the problems encountered in the analysis of the application can be treated with a level of abstraction that effectively hides the details of any specific technology that can be employed for interaction. Addressing the syntactic form of gestural interaction for developing applications brings benefits such as standardization. Any gesture described by grammar owns the same properties which also facilitates its extension. As perceived, the grammar only formalizes gestures of the upper body, which is not impossible to extend to the whole body, while still maintaining their properties.

With syntactic description, we still have the flexibility to create new commands or change existing ones without getting into conflicts with other gestures of the application. Moreover, their use facilitates the reuse of the generated code on these syntactic specifications.

A counterpoint to the benefits is the long description of the command. As a gesture is broken into several micro-gestures, its description results in an extensive sequence of combinations. This problem is more evident to commands that are naturally more complex. Another important fact is that the user will not be able to repeat exactly the same command, for example, with the same angles and rotations. In this case, it is needed to assign a tolerance concerning the recognition of the application.

Through semantic formalization of the application, all the features are displayed globally, helping developers to project more adequately gestures to their context; since there will be an explicit association of possible gestures with its functionality and the changes they caused in the environment, together with its feedback. Perform semantic formalization in an initial form in the development process will allow to analyze various recommendations of gestural interaction predicting possible interaction problems.

However, the semantic formalization described in this paper is referred to the application. It is not purely an analysis of gestural interaction. This other type of formalization yields many challenges of how to represent semantically and “precisely” the human gestures; since even representation by images of gestures also needs a caption to avoid ambiguity of interpretations. Also working the semantics of gestural interaction only discursively can give different meanings due to various forms of interpretation. Furthermore, there is an assignment of meanings also in facial expressions of users when performing gestures. A formalization of this level will help further the construction of a most representative vocabulary to the diversity of users, covering cultural, of learning and gender aspects, among others recommendations covered by Correia et al. [3].

In addition to the metrics, the questions prominent of the GQM approach are important in the construction of gestural vocabulary. Even without actually using the metrics in the analysis of the gestural vocabulary of the application, the knowledge of the goals and their questions help designers in a further reflection in building their own vocabulary for applications.

From this study, a set of indicators for each user profile can be investigated to adapt the gestural interaction of the application to the users. Indicators allowed to qualify a gesture described by the syntactic form in accordance with the recommendations/goals. As a hypothetical example, we can report that older users can perform arm movements to an angle of 80 degrees. From this indicator, it is possible to check through the metrics, a more appropriate set to the profile described, and can automate this analysis.

6 Conclusion

In this work, we present the syntactic grammar that abstracts and describes a wide variety of potential gestures for the interaction of a residential application, homogenizing its gestural vocabulary. Also, we present the semantic formalization of residential application that assists in building the gestural vocabulary, allowing a preliminary review of the application before its development. The metrics presented in this paper helped designers analyzing the application vocabulary.

As future work, we will discuss the formalization in the process of effective development of a gestural application, aiming at the personalization functionality that will assist users in their diverse preferences, and being guided by the metrics of this study.

Acknowledgements. This work was partially supported by the Brazilian Federal Agency for Support and Evaluation of Graduate Education (CAPES), by the Brazilian National Council of Scientific and Technological Development (CNPq grants #126942/2013-7 and #163408/2012-2), and by the Physical Artifacts of Interaction Research Group (PAIRG) at Federal University of Rio Grande do Norte (UFRN), Brazil.

References

1. Alahverdzhieva, K., Flickinger, D., Lascarides, A.: Multimodal Grammar Implementation. In: Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, pp. 582–586 (2012)
2. Basili, V., Caldiera, G., Rombach, H.: Goal Question Metric Paradigm. In: Encyclopedia of Software Engineering, pp. 528–532. John Wiley & Sons (1994)
3. Correia, A.C.C., Miranda, L.C., Hornung, H.H., Marciano, J.N.: Recommendations for Gesture-based Residential Interactive Systems Inspired by Diversity. In: 16th International Conference on Human-Computer Interaction. Springer (in press, 2014)
4. de Carvalho Correia, A.C., de Miranda, L.C., Hornung, H.: Gesture-based Interaction in Domestic Environments: State of the Art and HCI Framework Inspired by the Diversity. In: Kotzé, P., Marsden, G., Lindgaard, G., Wesson, J., Winckler, M. (eds.) INTERACT 2013, Part II. LNCS, vol. 8118, pp. 300–317. Springer, Heidelberg (2013)
5. Donmez, N., Singh, K.: Concepture: A Regular Language based Framework for Recognizing Gestures with Varying and Repetitive Patterns. In: International Symposium on Sketch-Based Interfaces and Modeling, pp. 29–37 (2012)
6. Doherty, G.J., Faconti, G., Massink, M.: Formal Verification in the Design of Gestural Interaction. Electronic Notes in Theoretical Computer Science 43, 75–96 (2001)
7. Hussain, A., Kutar, M.: Usability Metric Framework for Mobile Phone Application. In: 10th Annual Conference on the Convergence of Telecommunications, pp. 1–5 (2008)
8. Kammer, D., Wojdziak, J., Keck, M., Groh, R., Taranko, S.: Towards a Formalization of Multi-Touch Gestures. In: ACM International Conference on Interactive Tabletops and Surfaces, pp. 49–58. ACM (2010)
9. Kin, K., Hartmann, B., DeRose, T., Agrawala, M.: Proton: Multitouch Gestures as Regular Expressions. In: SIGCHI Conference on Human Factors in Computing Systems, pp. 2885–2894. ACM (2012)
10. Kin, K., Hartmann, B., DeRose, T., Agrawala, M.: Proton++: A Customizable Declarative Multitouch Framework. In: 25th Annual ACM Symposium on User Interface Software and Technology, pp. 477–486. ACM (2012)
11. Liu, K.: Semiotics in Information Systems Engineering. Cambridge University Press (2000)
12. Miranda, L.C., Hornung, H.H., Baranauskas, M.C.C.: Adjustable Interactive Rings for iDTV. IEEE Trans. Consum. Electron. 56, 1988–1996 (2010)
13. Ouchi, K., Esaka, N., Tamura, Y., Hirahara, M., Doi, M.: Magic Wand: An Intuitive Gesture Remote Control for Home Appliances. In: International Conference on Active Media Technology. IEEE (2005)
14. Spano, L.D., Cisternino, A., Paternò, F., Fenu, G.: GestIT: A Declarative and Compositional Framework for Multiplatform Gesture Definition. In: 5th ACM SIGCHI Symposium on Engineering Interactive Computing Systems, pp. 187–196. ACM (2013)
15. Spano, L.D., Cisternino, A., Paternò, F.: A Compositional Model for Gesture Definition. In: Winckler, M., Forbrig, P., Bernhaupt, R. (eds.) HCSE 2012. LNCS, vol. 7623, pp. 34–52. Springer, Heidelberg (2012)
16. Wilson, A., Shafer, S.: XWand: UI for Intelligent Spaces. In: SIGCHI Conference on Human Factors in Computing Systems, pp. 545–552. ACM (2003)