

# Contextual Analysis of Human Non-verbal Guide Behaviors to Inform the Development of FROG, the Fun Robotic Outdoor Guide

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**Abstract.** This paper reports the first step in a series of studies to design the interaction behaviors of an outdoor robotic guide. We describe and report the use case development carried out to identify effective human tour guide behaviors. In this paper we focus on non-verbal communication cues in gaze, gestures and movements. The work reported involves the observation of human tour guide behaviors and visitor responses as well as interviews with guides. An affinity diagram is used to identify effective communication cues of human guides and the relations between them. The opportunities for a robotic guide are discussed. We argue that human guide behaviors and strategies cannot be one-on-one applied to robot tour guides. Instead, we aim to develop abstractions of the human behaviors, appropriate for robot tour guides and effective in realizing visitor engagement. The results of this study will be used to create a first Fun Robotic Outdoor Guide prototype with the abstracted interactive robot guide behaviors implemented to assess the effects on visitor experience in ‘the wild.’

**Keywords:** Human Tour Guide Behavior, Non-Verbal Robot Behavior, Contextual Analysis.

## 1 Introduction

The EU 7<sup>th</sup> Framework project FROG (Fun Robotic Outdoor Guide [www.FROGrobot.eu](http://www.FROGrobot.eu)) aims to develop a guide robot with a winning personality and behaviors that will engage tourists in a fun exploration of outdoor attractions. The work involves innovation in the areas of vision-based detection, robotics design and navigation, human-robot interaction, affective computing, intelligent agent architecture and dependable autonomous outdoor robot operation. In this paper the focus is on the Human-Robot Interaction (HRI).

In many museums and tourist sites human tour guides are guiding visitors and convey information about the sites. However, not all visitors want to join or cannot afford a two hour guided tour. We believe that an autonomously navigating mobile robot can provide information to visitors in new and innovative ways.

The first step in developing the FROG-robot was to determine the requirements for the robot in the different tourist sites and identify opportunities to improve the visitor experience with a robotic guide. From this analysis it became clear that the FROG-robot needs to be available for small groups of visitors, will present some interesting and historical information and curiosities about the site and will guide visitors for a limited amount of time through a part of the site. The information conveyed will be based on the visitors interests [1].

The goal of the HRI part of the FROG project is to determine personality and behavior for the robot. We argue that using anthropomorphic communication cues will help visitors understand the robot, because humans naturally respond to non-verbal communication cues. The next step in the development of the FROG-robot, described in this paper, is exploring the non-verbal robotic guide behavior, such as gaze behavior, gestures and movements. This will be done by first observing and analyzing the human tour guide behavior, strategies and personality. Possibilities and limitations of transferring this behavior to robots will be examined based on literature.

In Section 2 the related work on robotic guide and communication behavior and human tour guide behavior is presented. The methodology of observing and analyzing behaviors of human tour guides and the visitor responses are given in Section 3 and subsequently the results of the analysis are reported in Section 4. Suggestions on how to apply the human behavior cues to a robot guide are indicated in Section 5. Finally, conclusions and future work are presented.

## 2 Related Work

Research on robotic museum guides has focused on various aspects. The robot Minerva, does quite a good job on interaction with visitors, because this robot is able to express itself in different moods [2]. The Robovie robot in the science museum does very well in addressing visitors and keeping their attention [3]. However, the interactions between the robots and the humans are still limited, because humans are still testing the boundaries of the systems [4], or are distracted by seeing a robot and lose interest in the exhibit.

Research has also looked into the influence of different modalities, e.g. the gaze of robots has been proven to be very important. As Mutlu et al. [5] found, robot gaze behavior influences the abilities of visitors to recall a story. When the robot looked at the visitors, the listeners could remember the story better than when the robot was looking around randomly [5]. Also gaze behavior in combination with pointing seem to be very important, because human tour guides' use of head movements at communication relevant places helps humans understanding the story told. Kuno et al. [6] tested these behaviors in a robot and the head movements were efficient for understanding the robot, too.

The robots mentioned above are (more or less) based on behaviors human tour guides show. Humans use effective guide behavior, so looking at the behavior of human tour guides may help setting the behavior of robotic tour guides. As Duffy states: using anthropomorphism and anthropomorphic communication cues can be powerful

and intuitive to make humans understand and naturally interact with robots [7]. We have to keep in mind that humans respond more rapidly to humans than to robots as Kanda et al. [8] found, because this will influence the human robot interaction.

However, the robots in these examples are only doing parts of the tour guiding, e.g. telling the story, but not interacting with human and conveying information very well at one exhibit, but cannot perform at another. Finally joining a robot tour guide should be as satisfactory as joining a human tour guide. So to determine effective behaviors for robot guides, it might be helpful to study effective human tour guide behaviors, strategies and procedures.

Some related work has been conducted in this direction with human tour guides. This work found that originally tours were like lectures and were more or less a monologue of the tour guide [9], but nowadays the tours have become more adjusted to the interests of the visitors which has the advantage that visitors are more involved in the tour and like the tour better [10]. To adapt the tour to the interest of the visitors, the guide needs to be able to tell flexibly about everything they encounter, so visitors do not notice the change in the tour when the guide makes changes in content, e.g. in case of some places of the trip not being available [11].

To give an engaging tour, guides use several strategies to get and keep the attention of the visitors. One of these strategies is to interact with them [9]. The interaction with visitors (e.g. verbal interaction) is important to keep the visitors' attention. And except from giving cues to the visitors, the guides also obtain a lot of non-verbal feedback about involvement of the visitors by looking at them. Visitors that are gazing at the guide or the object of interest and who are nodding or smiling are interested, the ones looking away or talking to each other may not interested anymore [10].

Robot tour guides as well as human tour guides should have behaviors and strategies that modify the tour in a positive way. For determining the robot behaviors, looking at human tour guide behavior might be helpful, as proven by the examples above.

### **3 Methodology**

To get insight in the effective human guide behavior, especially gaze behavior, gestures and movements, a qualitative research was performed by two researchers following four guides guiding different groups in two touristic sites. Notes taken during the tour, answers of guides in the interviews, notes from analysis of video data and notes of literature search were combined in analysis using an affinity diagram. The result of the research is a connection diagram and in-depth analysis of human tour guide behavior.

#### **3.1 Research Context**

For the analyses two different outdoor tourist sites with guided tours were selected. These sites were the Lisbon City Zoo in Lisbon, Portugal and the Royal Alcazar in Seville, Spain. Both sites offer interesting and challenging opportunities for having robot guides guiding visitors. In these sites the amount of information that is available

without a guide is not satisfying the visitors [1] and these sites offer outside environment to be covered by the FROG-robot.

The Lisbon City Zoo is a park showing several species of wild animals to humans and educating the visitors about nature and animals. Besides that, the Zoo also provides access for scientific research and participates in conservation programs for species. The guides giving tours in the Lisbon City zoo are educated and employed by the Zoo. Visitors of the Zoo are mainly families with one or two (young) children, couples with or without children, school classes and groups of friends. The day is experienced as a social day out.

The Royal Alcazar is a royal home, the first building was built in the ninth century and during ages Christians and Muslims built, destroyed and rebuilt the buildings in the site. The guides in the Royal Alcazar are educated and employed by different agencies or entrepreneurs. All guides must have certification, but the board of the Royal Alcazar does not control the guides a lot. The guides that contributed to this research were certificated. Visitors of the Royal Alcazar are mostly couples (with older children), groups of tourists and school classes. The purpose of the visit is to learn about the history of the site.

### **3.2 Sample**

For the research a total of four guides were observed, video-taped and interviewed. In the Lisbon City Zoo two guides participated. The first guide (male, ten years of experience) guided a group of seven adult visitors. The second guide (female, some years of experience) guided a school class of 19 children aged 9-10 years old. In the Royal Alcazar two guides participated, both were female. The first (ten years of experience) guided a group of eight adult persons, and the last guide (several years of experience) guided a group of twelve adults (and two small kids).

### **3.3 Procedure**

At the start of the tour all visitors and the guide were informed about the research and the filming. In the end of the tour the group was lead to a room and all adults completed a consent form.

Two researches joined the four tours. One of the researchers was video-taping the whole tour. In the tape the guide and his/her expressions and some visitors or the whole group of visitors are visible. The story is not always clear hearable on the tape, but non-verbal behavior of the guide and the visitors' responds is very well visible.

The second researcher followed the guide close and made notes on the story the guide told, outstanding guide behavior and on the events that happened during the tour.

After the tour the researchers interviewed the guides and took individually notes of the answers. When the guide had left, the researchers completed the notes of the observation of the tour and the interview.

### 3.4 Measures

Notes were taken during and completed after the tour on things that stood out about guide behavior. One of the researchers was following the guide close and took notes during the tour, the second researcher was filming and took the notes at the end of the tour.

After the tour, the two researchers had a short semi-structured interview (approx. 15 minutes) with the guides about the tour they just gave, their experiences guiding different kind of groups, use of strategies and how they would like to improve the visitor experience in the sites. (What is the purpose of your tour? / What is the main exhibit in the site you are guiding? / Do you notice differences between groups? How do you deal with that? / Is guiding children different from guiding adults? If yes, in what way? / How do you get and keep attention of the visitors? / What do you want to change to improve the visitor experience?).

All tours were videotaped to later look back at the actions of the guides and take notes of more specific actions and behaviors. Next to the global analysis, from all guides two film fragments (approx. 2-4 minutes) were taken to analyze in detail. Aspects that were analyzed were: the orientation of the guide, the story guides were telling, the movement and gestures the guides made, to what the guides were looking and how they ended at exhibits.

### 3.5 Data Analysis

The data gathered from the different researches was combined in the analysis using an affinity diagram. This method is based on Grounded Theory method; themes and results of the research emerged from the data. Using an affinity diagram is very useful when large amounts of qualitative data has to be analyzed, from which the results are complex and not easy to grab [12]. The affinity diagram helps to order the information and to find logic and natural relationships between the parts of the data.

Globally the method follows a few steps. First statements have to be written on cards (post-its or index-cards). These statements are remarkable in a certain way and are taken from all parts of the research. When writing down these statements, no attention should be given to duplications of text or solitary cards. For interpretation of the data color coding of the statements could be useful.

Second, all statements will be shuffled and pasted on a wall. Cards with similar statements will be pasted close to each other, but also other relations between statements can be made clear. In this phase clusters of similar subjects and relations between subjects appear. Important is that a statement can be in more clusters (by duplicating the card) and relations can be of all kind (e.g. cause, opposite, similar).

In the third step the clusters will be named and the relations between the clusters will get meaning. Some extra cards with the main findings per cluster will be placed to make the affinity diagram more easily readable. When the number of clusters is high, some can be combined in one larger cluster having some sub clusters. But also the other way around, when the clusters are very large, some sub-clusters can be made.

For the research on human tour guide behavior, from all research methods (observation, interview, video analysis and literature) statements and observations were taken and written on small cards. The statements were color coded by resource (e.g. all statements taken from the first observation were written in blue and statements taken from the interviews were written in purple).

When all cards were completed, the researcher started to cluster the statements on a large wall. During this clustering the placement of the cards was not fixed and cards were removed and replaced if necessary. Finally, all cards were pasted on the wall and names for the clusters were invented, some clusters with sub-clusters were invented. The main statements per cluster were added on yellow notes.

The final affinity diagram was quite large and to make it easier to read, a connection diagram based on the affinity diagram was made in which the clusters and sub-clusters and the relations between them are visible. These connections were counted. And five collections of clusters and sub clusters were found. In the result section the results for the analysis are given, and more explanations about results are presented in the connection diagram.

Please note that the statement cards and the affinity diagram were made by one of the researchers. However, the researchers were discussing the notes on the observations and the video analysis before writing the statement cards. After making the affinity diagram and the connection diagram the researchers discussed the results and added relations, connections and changed names for the clusters to get the best overview of the results.

## 4 Results

In the connection diagram (Fig. 1) the names of all found clusters are given and the clusters are connected with lines when there was some relation between them (e.g. the connection between distraction and taking pictures is that when visitors get distracted during the tour, they often start to take pictures or, vice versa, they get distracted because they take pictures). The clusters and sub-clusters with the most connections are highlighted in yellow. These are main aspects during a tour and the guides tried to do everything to influence these factors positively.

### 4.1 Clusters

Ten clusters with sub-clusters appeared, which are briefly described (detailed description and explanation of non-verbal communication cues follow in the next paragraph):

**Attention.** Without getting and keeping the visitors' attention a tour guide cannot give a tour. Guides used lots of strategies to get and keep the visitor's attention, such as interacting with the visitors and breaking eye-contact and starting to move in the next direction at the end of an exhibit.

**Interaction** is usual in tours these days compared with the past. All guides knew that a tour of two hours was too long for visitors to just listen to a guide. Therefore, the guides tried to interact with the visitors by addressing them in different ways, such as

asking and answering questions, showing visuals, letting visitors experience (touch, smell) the site, pointing at objects, searching for differences together and by asking for personal interests and referring to that later and having a chat with the visitors during the walk.

**Information** about the site is conveyed by the guide. The guide usually can tell flexibly about everything they encounter in the site, and answer all the questions of the visitors. Particularly, visitors like to hear curiosities.

**Adaptation** of the tour is always done to fit the tour to the different type of visitors. But also during the tour to keep visitors interested guides adjust the tour to the group. The guides try to shape the tour around the visitors interests, because when adding something new to a subject visitors were already interested in, it was easy for the guide to keep the attention. Adaptation can be in content, speed or route.

**Taking pictures** was something lots of visitors did when they were in an attractive place. Taking pictures either meant they were really interested, taking pictures of the subject of interest. Or it meant the visitors were distracted and they started walking around and taking pictures of everything. The visitors that were taking pictures during the tour were often lost and missed much of the story the guide was telling.

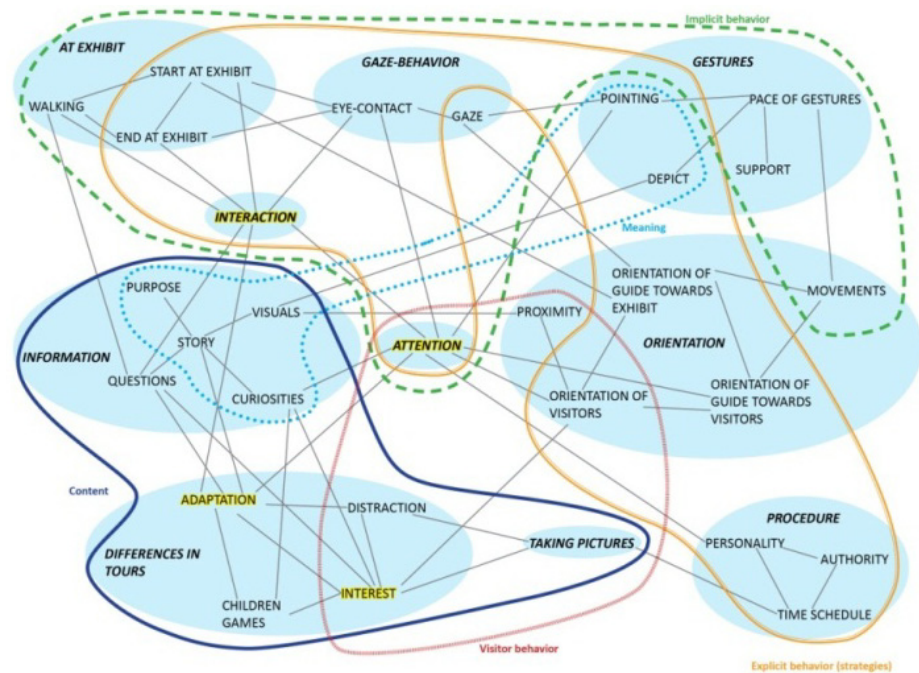


Fig. 1. Connection diagram of Human Tour Guide Behavior

**The procedure** of the tour is determined by the tour guide, following a tight schedule. The guides were not using authority for adults, because they could choose themselves whether they wanted to listen. The content was based on the visitor interests.

**Orientation** is the way guides orientated towards visitors and to the exhibit; always in a way visitors were able to see both the exhibit and the guide.

**Gestures** made by the guide might have helped the guide telling the story or helped the visitor understand the story. All guides made a lot of arm gestures, varying from supporting or depicting the story and pointing.

**Gaze-behavior** is quite intuitive, but guides used gaze to keep attention by alternating their gaze between visitors, and they were able to see from the visitors' gaze if they were interested. The guides adjusted the story to the ones they were looking at.

**At the exhibits** guides did start and finish with less important sentences, so all visitors were attended. To keep the tour going, the guides did not wait until the group was complete. They started to talk to the nearby visitors.

## 4.2 Effective non-Verbal Behavior

Given the page limit and the scope of the workshop this paper only describes non-verbal behavior, because this will give meaningful insights in the possibilities for the FROG-robot. The behaviors were classified as explicit behavior, or strategies the guides used, and implicit behavior. Explicit behavior is behavior the guides employed consciously to attract and keep the visitors attention. The guides were very different people, however, the strategies they adopted showed several commonalities. However, humans are sometimes not aware of non-verbal communication cues, still these cues could be very helpful for the communication. These cues used implicitly by the guides are also described below. Using strategies perfectly fitted in the guides' normal behaviors. Acting natural and naturally modify the tour in a positive way is what the guides wanted to achieve.

### Starting and Closing the Story

At the new exhibit the guide never started with the main story. To get the attention of the visitors at the start of an exhibit the guide started the story with some less relevant words or sentences. These can be "ok," or "so," or "this is a very beautiful view." When the group of visitors was not complete yet, the guides did start anyway to keep pace in the tour. When the guides wanted to tell something important and not all visitors were close, the guides raised their voices. The guides concluded with a short summary, telling where to go next or with words like "ok" "so" "let's go" to indicate they were finished at an exhibit.

### Gaze-Behavior

Gaze-behavior of the guide is important for the visitors' understanding of the story, but also the other way around. The guide obtains feedback from the gaze behavior of the visitors.



The guides reported in the interviews they alternated their eye-contact evenly between the visitors, as a strategy to keep their attention. The guides indeed were alternating their gaze, but in our analysis of the video material, the guides seemed to choose one visitor at each exhibit to talk to. Most of the time this visitor got the attention and the guide sometimes shifted attention to other visitors, but always got back to the chosen one. However, for different exhibits, the guides seemed to choose different visitors to address. The visitor the guide was looking at was often nodding, turning its head towards the exhibit and back and looked to the guide. This provided the guide with information about engagement of the group.

When pointing at an object of interest, the guides also looked at the exhibit for a while. For the guide, this was to check where to direct the group attention, but sometimes visitors reacted to it with looking into the same direction, following in mutual gaze. When the guides made the visitors look at an exhibit or visual, the guides decided when to go on with the story. Most of the time, the guides waited for most visitors to indicate they had seen it (by nodding or gazing at the guide again). To keep the story going, the guides did not wait for all visitors to look back. On the other hand, the guides sometimes provided extra time to look at something for a particular visitor, by adding non-important sentences to fill the time.

When the guides wanted to go to the next exhibit, they broke eye-contact with the group of visitors or focused their attention to another object or to the visitors in a social way and made a move towards the next exhibit. For visitors that made clear the story was over. And because the guide had moved slightly into the new direction during the last sentence, the visitors knew where to go for the next exhibit.

## **Gestures and Movements**

All guides used a lot of gestures, which can be categorized in pointing, depicting the story and supporting the story. While telling the story all guides used their arms to depict and point to the subject. The depicting of the story and pointing at objects is explicit behavior, the guide knows how, why and at which moment to perform the action in support of the story.

The visual support could be in the site itself, and the guide pointing and touching it, the guide could show visuals, and the guide was able to depict the story if the subject they were telling about was not visible at the moment.

Depicting the story and pointing to exhibits helps the visitor to understand the story the guide is telling. The guide will only depict parts of the story if the subject is not visible at the moment. Otherwise the guide will point to the exhibit to make clear what he/she is talking about.

When the guides walked away from an exhibit, they slightly moved in the next direction during the last sentence of the story. This made clear for the visitors the story was finished and which direction to go next. Sometimes the guides made a follow-me sign, and always the visitors followed like a chain reaction, the nearby visitors starting to walk first and the furthest visitors following last.

When looking at the pace of the gestures and the movements the guides made, except for using arm gestures there are no commonalities. These gestures and

movements were made unconsciously and might help the guide telling the story, at the moment is still not determined what influence they have on the transfer of knowledge. These gestures and movements were personal for each guide and fitted with the overall personality of the guides.

## 5 Discussion

The robot for the FROG-project is not envisioned to look very human-like, and simply copying the human communication cues and applying them on the robot may not be effective. However, using anthropomorphic aspects of appearance and behavior will be effective. How to design these anthropomorphic aspects, and what communication cues the robot will use depends on the human understanding of the appearance and adopted cues.

The FROG-robot will be approximately 1.20-1.50 meters high, smaller than an average adult to not scare the visitors. The robot will probably not have arms, because for a large not human-like robot unexpected moving parts can scare visitors or even worse, harm them. The next series of researches will give insight in the possibilities in pointing for a robot without arms. Now our intention is to abstract the different communication cues as much as possible, but still keep them intuitively understandable for humans interacting with the robot.

Explicit behavior and strategies the human tour guides showed, such as telling curiosities, addressing the visitors, breaking eye contact and moving in next direction during the last sentence, should be adopted for the robot. These strong cues in human-human interaction have to be translated and abstracted to fit the robot appearance and personality. So the strategies of a human tour guide might not have to be copied one-on-one to the robot, but the results in visitor behavior should be comparable.

From the implicit behavior it is important to look at the gaze behavior; the guides were alternating their gaze between the visitors, but tend to choose one visitor per exhibit to talk most to. When alternating their gaze, they always turned back to that one visitor, who gave the most (implicit) feedback. The visitors chosen were different per exhibit. Further tests should prove if this is important for communication.

The robot behavior when starting or closing a story will be similar to human behavior. The FROG-robot should get the attention at the new exhibit again, and therefore will not start with the most important information, but with a less important sentence. In the end the robot will break "eye-contact" to indicate the story at the exhibit is finished. Also starting to move to the next destination during the last sentence at an exhibit will be of importance for the robot to communicate to the group of visitors where to go next.

Also gaze is very important because humans use a lot of making and breaking eye-contact in human-human interaction. In human-robot interaction human communication cues applied to robotic guides help visitors to understand and recall the story [5, 6]. In the design of the robot gaze behaviors, examining the effective human gaze behaviors and translating them to effective robot guide behavior will probably help the robot conveying information.

Similar like human tour guides the FROG-robot will choose one of the visitors to get the main feedback from. Probably this will be the closest visitor, because the face would be easiest to track. This visitor will give information on the level of interest, by the robot examining the gaze direction, nodding and laughing. Further research will give insight in the necessity of alternating the robot gaze. For different exhibits, the robot will focus on different visitors, as not always the same visitor will be closest.

Looking into the exhibit when talking about a point of interest will be of big importance for the robot than for human. Because the robot will probably not be able to point with arms, other options will be considered. Looking at the exhibit is one of them (next to laser/projecting on the wall). Other than humans, the robot can look to the exhibit for longer period of time, because the “eyes” are not necessary the cameras that are examining the faces of the visitors.

Human tour guides use a lot of gestures, but the robot will not be able to do so. The function of these supporting gestures is not determined from the video-analysis. Depicting a story is important, but the robot will also not be able to depict the story with arms. The robot will have different applications to depict the story, by showing a film on a (touch-) screen, or projecting information on a wall. Also the visuals a human tour guide use, can be showed on screen or projected on the wall by the robot.

The FROG-robot will use some strong anthropomorphic appearance and communication cues to make the interaction with humans intuitive. To achieve this, effective human communication cues should be translated to fit the robot appearance. The non-verbal communication cues used for the robot will be the gaze behavior when talking about a point of interest, breaking eye-contact in the end, starting to move during the last sentence at and exhibit and showing visuals on screen or projection on the wall. Using these human communication cues in abstracted form should have the same result on visitor behavior and attention as the cues a human tour guide is using.

## 6 Conclusions and Future Work

Robots are more and more successfully used in human social environments. FROG aims to develop a Fun Robotic Tour Guide to guide visitors in indoor and outdoor museums and touristic sites.

This paper presents an analysis of non-verbal human tour guide behavior. The affinity diagram used was very appropriate to use for the analysis of the large amount of qualitative data from varying sources. The method led to a connection diagram, which presented the main aspects of a guided tour and the guide behaviors. To have insight in the behaviors collections were made. This paper focused on non-verbal behavior.

Strategies (explicit behavior) a human tour guide uses can be copied to a robot. Comparison with literature and own tests will give insight in how to use these strategies to achieve the same effect on the visitor behavior.

Implicit behavior of human tour guides includes behavior that helps the guide to tell the story, but it contains also behavior that helps the interaction with visitors. This behavior, like breaking eye contact and already moving in the new direction of the next exhibit will be very useful for the robotic guide.

To conclude, the observed human tour guide behavior such as gaze, showing visuals and movements will be translated to robot behavior and applied on a robot. In controlled lab-experiments, possible robot gaze, movements and orientation will be tested and evaluated on effectiveness, efficiency, understanding and experience of humans.

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