New Forms of Interacting with the Television in an Ambient Environment

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ABSTRACT
In the past there has been a lot of research in the area of human-computer interaction. With the arrival of digital television, the television becomes more and more like a computer. A new form of television is being introduced: interactive television. The only interaction with the television in the past was via the remote control. Interactive television provides opportunities for new interaction methods. Interacting with the television can for instance be done by communicating with an avatar or by speech control. Maintaining the passive character of interaction plays an important role in this paper. Several criteria are used to select a proper interaction method. Interaction occurs via interfaces commonly used in ambient environments. The method that fits those criteria best is interacting with the television via speech control.

Keywords
Ambient intelligence, ambient environments, interactive television, interaction methods, speech control, avatars, user interfaces.

1. INTRODUCTION
Computers can be found everywhere in your home. Almost all domestic devices contain computer chips. An ambient environment also contains a lot of computers or other devices which can be used to fulfill several human needs. The television is an example of a device which is turning more and more into a computer. New opportunities will be created for the television. This paper investigates how the interaction between the user and the television changes by this digital revolution in an ambient environment.

1.1 Related work
There are two key aspects in this research, the first one is of course the television and the other is ambient intelligence, specially ambient environment. A lot of research is performed in both areas. In [1] a domestic environment is built in which several scenarios of ambient intelligence are tested. The focus here is especially on improving experiences using visual displays. We handle interaction as in [2], where interaction with the environment is no longer described as human-computer interaction, but as human-environment interaction instead.

De Ruyter et. al. [1] describe ambient intelligence as electronic environments that are sensitive and responsive to the presence of people. In the future there will be more and more electronic devices integrated in the houses of people. Those devices will provide communication, information and entertainment. The environment reacts on the presence of the user. Cameras and sensors are used to respond on actions performed by the user. Lights can be switched on automatically when a user enters a room, curtains can open in the morning when you have to get up and so on.

All research will be placed in an ambient environment, because there are some interesting interfaces that are common in these environments. These interfaces can be used to interact with the television. If you look at television associated with an ambient intelligence point of view you get some interesting concepts. In [3] television is not considered as a content medium, but as a secondary function to other activities. Normally the user is not focused on other things when watching television. If watching television becomes inferior to other tasks like socializing with friends or doing something else besides watching television, your interaction with the television changes completely.

There has been research on several aspects of interaction in an ambient environment. An interesting article in this area is [4]. This article is about interaction in a domestic environment. Here they control the atmosphere in a room by various methods of interaction. The focus of my investigation will be a bit similar to this approach but instead of changing the atmosphere in a room the focus will lie on different methods of interacting with the television. The interfaces that are used are still very interesting to consider, because these interfaces can be used as interfaces to interact with the television as well.

An example of a new method to interact with the television is listed in [5]. Here computer graphics are used in a way that people can create their own three-dimensional avatars in the televisions user interface. [6] discusses another new way to interact with the television by using a remote control which can be adjusted to your personal preferences. It is also interesting to look at another domain to look for interaction methods. [7] is for instance about interacting in a new form of virtual theater. Some of these methods might be interesting and usable for interactive television.

1.2 Problem statement
This paper presents an overview of methods to interact with the television in an ambient environment. In order to select the proper methods of interaction, interactive television and its properties need to be analyzed. Section 2 starts with defining television itself and extends it to interactive television. The most important choice is whether you want active or passive interaction, since television has always been a passive medium. Some criteria are listed at the end of section 2, to determine whether the selected interaction method is appropriate.

After the television ambient environments will be discussed. Section 3 first defines what is meant by ambient environments. Section 4 describes different kind of interfaces to interact with the environment and section 5 describes the advantages and disadvantages of these interfaces. In section 6 the best interfaces in ambient environments are used when discussing interaction methods with interactive television. The next sections contain
a discussion whether the suggested interaction methods are relevant enough to use in future television design.

2. INTERACTIVE TELEVISION

Watching television is the most popular leisure activity for more than half a century now. Television has always been a passive medium, the user turns it on and watches a program. Only the channel and the sound volume can be changed by the user. In this form television is not an interesting medium if you consider it in combination with ambient intelligence. The last years however have brought a change, the television is becoming a digital medium. Digital television provides endless opportunities for new forms of user interaction that did not exist yet.

2.1 Definition of television

The fact that digital television provides the opportunity for more user interaction should not be brought too far though. As said before television always was a passive medium. With digital television it should still be possible to just turn it on and watch a program with minimal form of interaction. To define what we mean by interactive television we start looking at the basic principles of television [8]. Without these principles the user experience is no longer the same as the user experience from television. The foundations of television are:

- Information is collected in a passive manner.
- It can be used by multiple users at the same time.
- It is on a distance of several meters from the user.
- The television can be controlled by a remote.
- There are only basic control functions (channel numbers, cursors etc).
- The television plays videos using its complete screen.
- The quality of the images is good and constant.

2.2 Digital television creates interactive television

Digital television is the step from an analogue tv-signal to a digital signal. This means of course a better image and sound quality, but besides those things it provides manners to interact apart from just adjusting the channel or volume levels. It is now possible not only to receive information but also to send information. You can use this for instance by playing interactive games, like participating with a television quiz at home. Another way is to request some background information while watching a certain television program. An important change is furthermore that you are no longer required to tune in at a specific moment. By using a video on demand function you can watch the program you like at a time you prefer.

2.3 Interaction criteria

All these new forms of interaction might be very interesting, but there is a downside to it. Watching television becomes more like operating a computer. It would not bother for some people, but it does for people who just want to lean back on the couch and watch some television. At this point you need to choose between active and passive watching of television. Since television has always been a passive medium over the years and we want to distinguish a television from a computer, it is considered as such in this paper. To determine what forms of interaction are considered passive and what forms are considered active the interaction methods will be tested by a few criteria introduced in this section.

Another important aspect of watching television is the fact that the user can remain seated when interacting with the television. So besides preserving the passive character of watching television, the user should be able to stay on the couch when interacting with it.

2.3.1 Usability

Interaction with a remote control is very straight forward, if a user has seen one remote control he can pretty much interact with all television sets. When you change your way of interaction it could get complicated. Especially with the arrival of digital television, usability becomes an important issue. Digital television provides many new opportunities, but new functionality can be less obvious compared to a standard remote control. In this paper we are looking for methods of interaction which are easy to use and which should not be studied for hours until one can use them. The reason for choosing methods of interaction which are easy to use is keeping them accessible for the widest group of users. Another reason is the fact that we want to keep watching television a passive activity. It is contradictory if you must read a manual before you can watch some television.

2.3.2 Number of steps

Because interaction with the television using a remote control provides limited options to interact, the number of steps a single adjustment takes is a few presses of a button at most. Different ways of interacting, especially when adding extra functionality, will probably leave you with more steps to make a single adjustment. This fact seems inevitable, however it should not be the case that you have to operate your television set like a computer and that it takes more than ten steps to change your channel.

Therefore another criterion when selecting interaction methods is to chose the method which uses on average the fewest steps to make adjustments. Again by assuring that you maintain the passive character of watching television.

2.3.3 Number of possibilities

The newly selected interaction method should not only be easy to use and in a limited number of steps, but should most importantly add some new possibilities compared to the remote control. This criterion is a tricky one however. The most important issue is the fact that watching television must remain a passive activity. Adding an endless amount of new possibilities, like tv-guides, the ability to access the internet etc., have the side effect that operating the television becomes more active.

The last criterion is therefore that at least the basic functions, as present on the remote control, should also be present on the new interaction method without losing the passive character of watching television. More functionality besides that is considered positive too, because new possibilities add something new to the experience of watching television.

3. AMBIENT ENVIRONMENTS

Ambient intelligence is a vast research area. The most important factors of ambient intelligence are the fact that the system is embedded in the environment, the environment can recognize users in it, users can personalize the environment and the environment changes itself in response to the user [1]. The concepts which can be applied to interactive television will be discussed. This section discusses the fact that users can be located and tracked in an ambient environment, the environment reacts on the presence of the user. An extension to this is the learning factor, the environment can learn from previous actions performed by the user. The section ends by applying the tracking and learning aspects on interactive television.
3.1 Presence and awareness
If we place a user in an ambient environment, that user must interact with the environment in some way. Creating an interface based on human environment interaction starts with the implementation of two key aspects; presence and awareness of the user in such an environment [9]. The user no longer controls aspects of the environment by explicitly pressing buttons to turn on the light for example, but the environment controls itself by adapting the lights when a user enters or leaves the room. The environment keeps track of the location of the user and controls the environment according to the position of the user. This can be achieved using cameras or motion sensors to check whether a user is in a specified room. Another way to keep track of the user can be achieved by using pressure sensors to check whether a user sits on the couch or not, as proposed in [10].

3.2 Learning from feedback
The environment can interact with the user by reacting to the presence of the user. Since we are dealing with a smart environment you expect the environment to learn from previous actions and thereby adapting itself to user preferences. In order to do so the environment should get feedback from the user. Basically you have three kinds of feedback; positive, contrast and negative feedback [11].

- Positive feedback is the case when the user agrees with the actions performed by the environment.
- Contrast feedback occurs when the user achieves the same goal, but by executing another action than proposed by the environment.
- Negative feedback is when the user undoes the action executed by the environment.

The environment uses the feedback to update itself. In case of positive feedback the environment can increase its autonomy, meaning it can execute the same action again because the user agrees with it. In case of contrast feedback the environment decreases its autonomy, the user executed an action different to the one executed by the environment. Negative feedback is more difficult because the user only undoes his action, but does not give the environment an alternative action.

3.3 Television and ambient intelligence
Normally people just watch television and that is it, but there are several ways to increase this experience by placing the television in an ambient environment. To increase this experience you have to make some changes to the environment, not only to the television itself. Using living lights, as presented in [1], is an example. This is about the concept of so called light speakers. There are several speakers like a surround sound system situated on the left, right, top and bottom of the television set and a sub light underneath the couch. The idea as presented in the article uses light scripts, which are created for specific music or movies. A system like this exists nowadays, created by Philips [12], which is called Ambilight. This system has indeed light speakers on all sides of the television, but instead of using light scripts to determine the color and intensity of the lights it uses the colors on the television screen.

The various aspects of ambient environments can now be combined and compared with regard to interactive television. Usage of keeping track of a user applied to television will most likely be limited. While watching television the user remains seated, since the user is not walking around, it is not desirable to use the presence and awareness aspects on a great scale. The aspects can be used to turn the television on and switch it off when the user enters or leaves the room, but this usage seems unlikely since you do not want to watch television every time you enter the living room. On the other hand it can be useful to turn the television off when a user left the room for a specified time to save energy.

Depending on your interaction method, a learning system can have benefits for the user. The next sections describe different interfaces which can be used in ambient environments. These interfaces are later applied to interact with the television and for some interfaces it can be interesting to improve the interaction method using feedback from the user.

4. AMBIENT INTERFACES
The environment can adapt itself automatically to the preferences of the user. This form of interaction alone is not enough, because the user cannot interact with the environment yet, except by entering or leaving the room. Therefore there need to be some kind of user interface which can be controlled by the user. This section describes a tangible interface, a speech interface, a graphical interface and a gesture interface. These interfaces are most suitable in an ambient environment and can later be used to interact with the television. Only the properties of the interfaces are discussed, section 5 describes what the advantages and disadvantages of the different interaction methods are when using them as interfaces to interact with the television.

4.1 Tangible interface
In a tangible interface the user interacts via touch. The interface has buttons, switches or pressure sensors which can be set by the user. An ordinary remote control is actually a tangible interface.

Another prototype of an implemented tangible interface is developed by Ross & Keyson [13]. The interface can change the atmosphere in the living room by controlling audio, lights and other visual aspects. The prototype is called ‘the carrousel’, see figure 1, and consists of a main body with four flaps attached to it. The user operates the device by adjusting the positions of these flaps. While designing such a prototype there are a few important design principles. The interface should be part of the interior and should therefore look and feel as an appropriate object. Operating the device should be natural and intuitive for the user.

Another example of a tangible interface has a completely different look. Nack et. al use a pillow as an interface [14]. The pillow is operated by a touch screen, which consists of some pressure sensors. Furthermore it contains beepers, vibrators and

Figure 1. The Carrousel by Ross et. al. [13]
lights used for local feedback. The pillow is used to control several devices in your house. One of the mentioned functionalities is using it as a remote control for the television. The pillow can be used to change the channel or adjust the volume.

4.2 Speech interface
Interacting with the environment by speech is an opportunity widely researched. Controlling devices with your voice should be very simple and it has the advantage that you do not have to move or fulfill any physical labor. Changing the atmosphere in your living room can be done by simply saying what you would like to change in [4]. If you want a more romantic atmosphere you just say ‘more romantic’ and the atmosphere is changed as such by adjusting the lights and playing the right music. The system works with the keyword ‘more’ and ‘less’ followed by a specific preset.

4.3 Graphical interface
A graphical interface gives a visual representation of the state of the system. Graphical interfaces are frequently used in multiple devices. Computer and television menus are examples of graphical user interfaces. Graphical interfaces can be used in an ambient environment for controlling different devices. Controlling your lights can be done with a touch screen, where you can set the color and light intensity for instance.

4.4 Gesture interface
A complete different way to interact in an ambient environment is using gestures. The environment keeps track of the user with cameras and sensors. If these cameras and sensors have the ability to recognize certain gestures from the user, the environment can use this to control devices including the television.

Coogan et. al. developed a system which performs real time recognition of gestures [15]. This system can recognize gestures from both the face and the hands using a video camera. Recognition of gestures is done by several aspects. The color of the skin is used to determine where the system should focus. The position and more importantly the shape of the hands on the screen are used to determine what specific gesture the user gives. The user has to learn some gestures as in sign language. The system can recognize these signs. Apart from static gestures the system can also detect simple dynamic gestures, like rotation of the hands to adjust the volume when watching television.

5. APPLYING INTERFACES TO TELEVISION
The interfaces discussed in the previous section can be used to interact with the television in an ambient environment. This section describes whether the interfaces are appropriate to use as an interface to interact with the television.

5.1 Tangible interface
Tangible interfaces can be used to interact with the television, the remote control itself is an example of a tangible interface. The pillow interface [14] has only the basic functions of the remote control. This interface is not improving the usability of the ordinary remote control. An advantage is that the user can interact with the television using a pillow which is in reach when sitting on the couch. The carrousel [13] is originally not a television interface and is therefore harder to compare. The carrousel has only four buttons in the form of flaps for the user to interact with, it would therefore most unlikely that you can get the same functionality as with the remote control. The number of steps one has to take to perform certain actions increases because there are only four buttons. Performing basic functions with a tangible interface can still work, but when a more complex task needs to be performed you also need a more complex tangible interface than the ones in section 4.1.

5.2 Speech interface
A speech interface could be used to control your television. There are several advantages compared to the remote control. Operating the speech interface is even more passive and the main advantage is that you can perform, otherwise complex tasks, by simply saying what action you would like to be performed.

There are also some disadvantages. Speech commands are probably not recognized at all times when using a speech interface for the first time. Using the interface more and more should decrease this problem, the environment can learn from previous times as discussed in section 3.2.

When looking at the criteria they are all positive. Operating devices using speech control is very simple by saying what you would like to happen, so your usability is good. The number of steps is in most cases reduced to one and there is more functionality without losing the passive character of operating the device.

5.3 Graphical interface
Applying a graphical interface for interaction with the television can be quite useful. The remote control can be replaced by a small handheld device containing a touch screen. Using a graphical display has the advantage that you can use it for all kinds of different tasks and that you are not limited by the number of buttons as with a remote control.

There are some restrictions however. Usability can differ much. A display, like a touch screen, can be easy to use with the condition it has a clear interface. The number of steps and possibilities using a visual interface can also differ, a lot is depending on the specific implementation. If an interaction method using a display is chosen, the main point of attention should be keeping in mind that it must not get too complicated since the passive character of watching television stays the most important factor.

5.4 Gesture interface
A gesture interface can be a very interesting interface to control your television. Basic functionalities from the remote control can be easily implemented, because they require only a few commands and the system as used in [15] was successfully tested with 28 different static gestures. Like the speech interface you can add extra functionality without losing the passive character. The user can give a complex command in one gesture.

There are also a few downsides. The user has to sit in the right position of the camera, otherwise the system misses the commands. There also needs to be enough light in order for the camera to capture the gestures. When laying back on the couch with dimmed lights there could be a problem with the position of the user and there is probably not enough light for the camera to capture the gestures.

Considering the criteria from section 2.3 a gesture interface is very interesting. The usability is high, although you have to learn the commands by heart first. Since a system created in [15] can recognize enough gestures, the number of steps you
need to perform is very low and this also assures that the user can give complex commands using a single gesture.

5.5 Competent interfaces
All interfaces have some advantages and disadvantages. The main goal of this paper is to find an interaction method that is competent to use on the television in an ambient environment. The most competent interface for this interaction method cannot be pointed out yet. In the next section there will be a discussion about some researches on interaction methods with the television. The interfaces discussed in this section will be used.

6. IMPLEMENTATION OF INTERFACES
There are multiple possible interfaces which can be used to interact in ambient environments. The researches that are discussed in this section implement some interfaces which are common in an ambient environment, discussed in the previous sections.

The new interaction methods for the television described in this section are some enhanced alternatives for the remote control. First the implementations of the researches are discussed, these implementations will be placed in an ambient intelligence context at the end of section 6.

6.1 3D avatars
When using a remote control there is only a limited form of interaction. The user clicks on a button and the channel changes, but the user does not really react on information provided by the television. A way to change this is by using a three-dimensional avatar. An avatar is a computer generated person-like image. Arita et. al. describe interaction via an avatar and show that communication via an avatar can be useful [16].

As you go through the menus of your television, for instance to check the tv-guide, the avatar guides you through it. The idea behind is that you can interact with the avatar, you make clear to the avatar what you would like to do. In order to communicate with the avatar as if it is a human being, it has to look as natural as possible according to [5]. Both verbal and non-verbal behavior from the avatar should look normal, this is achieved by implementing some rules for the avatar. The most important rule is that the avatar is never motionless, even if the avatar is not talking. Furthermore some motion from the eyes and eyebrows is added and the avatar blinks occasionally.

It is questionable whether an avatar should look as natural as possible, it might be better to use a cartoon-like figure. The problem with avatars is the fact that they probably do not look natural after all, a cartoon does not have to look natural and can therefore be used as a disguise [17].

6.1.2 Usage
Interacting with an avatar seems quite normal when you are used to play videogames where avatars are commonly used, but not everybody who watches television is familiar with avatars, let alone communicating with them. In order to prevent most problems with communication, communicating with the avatar should be as communicating with another human being. Therefore the avatar should use speech, general gestures and facial expressions to communicate with the user [5].

Interaction with an avatar can be achieved by different interfaces. In [5] a graphical interface is used to display the avatar. Considering placing the avatar in an ambient environment there are a few more interfaces which can be used. The user can command the avatar using a speech interface as discussed in section 4.2. A gesture interface as in section 4.4 might be another possibility, although the interaction can no longer be compared to natural interaction using gestures.

6.1.3 Usable as interaction method
An avatar might look appealing but there are some general disadvantages when concerning the proposed interaction criteria. The usability of avatars is probably low for users who are not familiar with them. The creators of this interaction method try to avoid difficulties in usability by ensuring the natural looks of an avatar [5]. This might solve some problems, but people who have never seen an avatar before still need a manual.

The number of steps a user has to take is less when using the avatar. Of course this is only the case if you can work with the avatar correctly. Communication with the avatars should feel the same as communicating with another human being, the avatars uses speech and gesticulating to achieve this.

Basic functionality can be performed when using the avatar, there is a downside to this however. It will cost the user more time to interact with the avatar. Concerning difficult tasks this is not a problem, but when you want to execute a simple command like switching a channel it will be much quicker to use your remote control.

6.2 Speech control
It is also possible to control your television set with your voice using speech control. Speech recognition has been used in many devices in the past such as cellular phones [18]. A speech interfaces in commonly used in ambient environments and is described in section 4.2.

Nakatoh et. al. use a special remote control, allowing the user to literally tell the television what to do [19]. This interaction
method uses the speech interface from ambient environments as described in section 6.2.

6.2.1 Implementation
Speech recognition for the television works with a special remote control. Different from the ordinary remote control this one has only a few buttons. Only basics functions like previous and next channel and audio volume settings are present, but the functionality should be the same as an ordinary remote because of speech recognition.

The speech remote control is a small device that fits in your hand palm. If you want to perform a simple, standard operation you can use one of the buttons, as with an ordinary remote. For more complex operations, which take a few steps normally, you can use speech control. The speech remote has a special button, if you press it you can give a speech command by talking into the remote.

6.2.2 Usage
Using the speech remote control should be very simple. You can select a channel by simply saying the channel number, or some nickname you specified earlier. Although this feature already saves some time, the remote comes in real handy by performing more difficult operations. You can for instance use the command ‘soccer’ if you would like to see some soccer. If you would perform a command like that on an ordinary digital television, you had to select the main menu, go to program control, to sports and finally to soccer. The essence of speech control is therefore the fact that you can select features which you formerly needed to find in some submenu.

6.2.3 Usable as interaction method
Speech control is real easy to use and straightforward. The speech remote control is actually smaller than the ordinary remote control, but there is no functionality lost. You do not need to have great expertise with certain techniques to operate the device and speech control is therefore appropriate for a wide selection of users.

An advantage of speech control is the fact that you can give a command and it will be executed. It does not matter if you are executing a basic or more complex command, it will not cost you more effort since the user only gives voice commands. Ideally the number of steps is always one, speech control gets close to that.

By adding more options to the interaction method the passive character of watching television is lost by most interaction methods. But since the number of steps a user has to take to execute a command is always more or less the same, the passive character is maintained using speech control.

There are also a few disadvantages as mentioned in 5.3. The commands are not always recognized, especially since there is always background noise (from the television for example).

6.3 Using the methods in an ambient environment
Section 6 describes two implementations of interaction methods for the television. Communicating with avatars can be interesting considering the ambient environment. Interfaces described in sections 4 and 5 can be used to implement this interaction method. Visualizing the avatars can be done with a graphical interface and communicating with the avatar can be accomplished using the speech and gesture interfaces. Not all criteria from section 2.3 are positive considering avatars. Avatars are not as easily controlled as a remote control, but the number of steps one has to take to communicate are very small and the number of possibilities are great.

Speech control fits perfectly in an ambient environment. The speech interface described in section 4.2 can be used to implement the interaction method described in 6.2. Speech control as described in section 6.2 also uses a tangible interface, in the form of a simplified remote control. Opposed to the avatar speech control is also promising when you take usability into account. Speech control is as easy to operate as a remote control.

7. SELECTING INTERACTION METHODS
In ambient environments interaction occurs via tangible, speech, graphical and gesture interfaces as discussed in sections 4 and 5. The opportunities for interaction with digital television in an ambient environment are endless. When comparing the different interfaces the most important factor is the passive character of watching television. Despite the fact that digital television provides lots of opportunities for new ways to interact, you do not want the television to turn into a computer since this totally destroys television as a passive medium.

As stated in 2.3 television should stay a medium which the user should be able to control from one place. The user turns it on, leans back and enjoys the show. If you would like to keep television passive and want to reduce interaction to a minimum, you only need a new method of interaction which is easier or faster to use than the familiar remote control. Another criterion is adding extra functionality to the interaction method. Speech control has the advantage that it can be used for advanced functionality without making it very complicated, by simply using your voice. Applying extra functionality to avatars makes it complicated for the average user, because interaction with the avatar is not always as easy as interacting in real life. The passive character of watching television is also better preserved when using speech control.

In ambient environments there are multiple interfaces to interact. Section 6 uses these different interfaces to implement 3D-avatars and speech control. An interesting concept is that both interaction methods use multiple interfaces in an ambient environment. Speech control uses of course the speech interface and a tangible interface. An avatar also uses the speech interface, the graphical interface and a gesture interface. Combinations of interfaces can be the key in finding new interaction methods.
8. CONCLUSION

Since the arrival of digital television in the last years interactive television is a phenomenon seen more and more. User experience plays a key role in ambient intelligence. This paper situates interactive television in an ambient environment. There is looked at different manners to improve or change the way to interact with the television. Formerly users had only the remote control to operate the television. But many other forms of interaction are possible.

Ambient environments have multiple interfaces, so different manners for the user to interact with it. Combinations of different interfaces seem to be the most adequate methods to interact. The interaction methods using avatars and speech control, discussed in section 6, both used multiple interfaces from the ambient environment. These interaction methods have great potential to improve interaction with the television without losing the passive character. Speech control seems to be the best choice when considering the criteria from section 2.3. It is easy to use, the user can give complex commands with his voice and it can be extended with extra functionality in the future. The basic functions are working quite well already, but it can be improved by implementing more complex commands, like recording programs or browsing the tv-guide on your screen, using voice commands.

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