

Animated Autonomous Personal Representatives

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1. ABSTRACT

We describe the research goals and issues in constructing autonomous personal representatives, and the desirability of using synthetic characters as the user interface for such artifacts. An application of these autonomous representatives is then described in which characters can be attached to a document to express a user's point of view or give guided tours or presentations of the document's contents.

1.1 Keywords

Avatar, Self-Presentation, Autonomous Agent, Synthetic Character

2. INTRODUCTION

You can't be everywhere at once. Over time several means have been developed to allow individuals to create artifacts which can represent them to others in their absence. Common examples are the phone answering machine, resumes and portfolios, application forms of various types, and dating service profiles and videotapes, all of which offer relevant information in the absence of interacting with the 'real' person. With the increase in popularity of the Internet, the use of computerized representatives has been increasing, including personal web pages and email auto-responders such as the UNIX vacation program [21], which provide absent users a way to interact with others in a simplified way. At a somewhat greater level of sophistication, the Office Monitor project at Sun Microsystems Laboratories [26] has as its goal the

construction of a personal representative located in an office (in the form of a dedicated computer or intercom device) with which co-workers can interact to leave messages and get information when the owner is out. All of these artifacts provide absent users a way to interact with others with varying degrees of interactivity, functionality, and presentation of self.

Of all existing forms of personal representative artifacts, personal web pages are the most advanced in terms of their global reach, their ability to interact with multiple users at one time, and the communication modalities authors have at their disposal. The ability for an individual to develop a personal web page (see Figure 1) and publish it to the world with minimal effort and cost is at least partly responsible for the growth of the world-wide web. With the construction of personal web pages, the Internet provides a unique opportunity for people's representative artifacts to truly be everywhere at once. However, the state-of-the-art in personal web pages consists mostly of static information and images, along with a "mailto:" link to let readers leave messages for the author. While this represents a great improvement over any prior technology, it is still greatly impoverished relative to interacting with the real live person behind the web page.

To understand some of the issues in personal representation, we are in the process of conducting user studies into the use of personal web pages in professional work environments [4]. Preliminary results indicate clearly that, in most environments, users feel the ability to

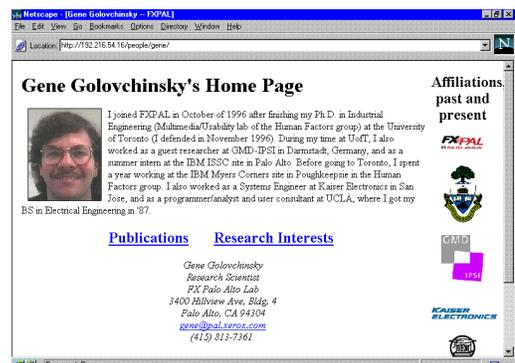


Figure 1. Example Personal Web Page

personalize their page is very important. Even in settings where *pro forma* pages exist, small personal touches are in evidence. In terms of use, users perceived the greatest benefits from having web pages to be the ability to disseminate information without being bothered by personal requests (and, conversely, to obtain information without bothering someone else). Most participants also expressed a desire to know how their personal pages were being used by co-workers, and liked the use of photographs on both their own page and the pages of others (e.g., “it lets you get to know someone better,” “it lets you understand their personalities”). This early work indicates that autonomous personal representatives with even more functionality and capability for expressing one’s persona should be well accepted.

We propose that other technologies could be applied to advance the state-of-the-art in personal web pages and other existing personal representative artifacts. Specifically, we believe that autonomous agents and synthetic characters provide new opportunities for constructing advanced personal representative artifacts which can not only perform a broader range of functions, but which also do a much better job of presenting an individual’s persona to those who interact with it. In the rest of this paper we discuss the issues in the design and development of autonomous personal representatives which exploit these technologies, followed by a description of an initial application we have developed in this area to gauge the acceptability of such systems in the workplace.

3. AUTONOMOUS PERSONAL REPRESENTATIVES

The construction of autonomous personal representatives represents a vast research area touching on issues in four major areas: visual representation (synthetic characters), multi-modal communication (verbal and non-verbal), behavioral representation (system autonomy), and the psychological issues in creating an electronic ‘self’ (self representation). Tangential to these, but crucially important, is how these systems can be made authorable by end users. In this section we outline some of the key research issues in each of these areas.

3.1 Synthetic Characters

Synthetic characters are 2D or 3D animated graphical representations of humanoids or other creatures. Recent research has focused not only on how to make the appearance of these characters more lifelike, but also on how they can be given the ability to operate autonomously [2],[11].

The use of visual representations of oneself has been written about extensively in connection with social interaction within virtual worlds environments on the Internet, such as OnLive [15] and the Palace [16] (see Figure 2). Here, individuals represent themselves through

graphical embodiments or ‘avatars’, which are essentially remote-controlled digital puppets. Most of these systems allow users to construct customized avatars, or select them from libraries (as in Figure 3), and then animate their behavior to varying degrees. Clearly the design or selection of avatars and of synthetic character representatives share some common research issues. However, as digital puppets, these avatars provide no useful functionality once the puppeteer walks away from the keyboard (although some research is underway into the issue of automating some aspects of an avatar’s behavior such as gaze control [25] but assumes that the user is still in continuous control of the rest of the avatar’s behavior).

Much has also been written on the pros and cons of anthropomorphizing a user interface in general. Anthropomorphic interfaces have been found to be likable, engaging and comfortable (at least in one application domain [8]) and provide the opportunity for an author to express their personality in a very direct manner. Most importantly, however, it is likely that users will want to be able to provide their personal representatives with their



Figure 2. Scene from the Palace



Figure 3. Examples of Avatar Individuation in the Palace

visual likeness given the choice, just as many personal web pages contain photos of their authors.¹

Certainly, evidence suggests that most users prefer a representation they can identify with [7]. However, while we are primarily interested in applications in professional work environments where we imagine that end users will want realistic representatives, the model from virtual worlds of changing one's likeness radically (typically gender and species changes [19]) could be applied to personal representatives as well. For example, an end user may specify multiple representations for themselves which iconically encapsulate the particular representative's expertise (e.g., "Carleen the Administrator" vs. "Carleen the Recreation Coordinator").

3.2 Multi-Modal Communication

Anthropomorphic interfaces provide the opportunity for personal representatives to use the metaphor of human face-to-face communication in user interactions. Given the appropriate sensory inputs, such representatives could engage in multi-modal discourse with users approximating face-to-face conversation with the author. This would include the recognition and use of gestures, facial expressions and body posture, and the more traditional verbal channels afforded by speech and natural language understanding and synthesis modules [23].

Some of the unique research issues in this area relative to personal representatives are:

- How to trade off the personalization afforded by recorded speech with the flexibility of synthesized speech;
- At what level should a representative's communicative acts be scripted vs. being generated from more general communicative goals;
- Which aspects of communicative behavior are generic and which can be tailored to achieve personalization?

3.3 Autonomous Systems

What does it mean for one's representative to be autonomous? Several criteria are specified in [12], the most relevant of which are that the representative must be able to operate independently from its author, and must be able to fulfill its goals in a complex dynamic environment. The range of behaviors that an autonomous representative could have include:

- Providing information about its author;
- Voicing the author's opinions and personal preferences;
- Relating and applying the author's expertise in certain narrow domains;

- Relaying messages to the author; and
- Making commitments on behalf of the author.

Considering the use of autonomous personal representatives in general, there are many interesting research questions and issues to be addressed. For example, how much authority should a representative be granted? Can it make commitments on behalf of its author? Should it be trusted with a credit card? How good is a representative's word?

If an author's representatives are truly *adaptive* autonomous agents [12], is it important that the things they learn be shared with each other to ensure consistent behavior? Should this information always be fed back to the author as well (since self-monitoring is a crucial component of self-presentation [10])? And if a user interacting with a representative knows that its author is watching the interaction (synchronously or asynchronously), how does that change the nature of the interaction (cf. the notion of de-individuation in psychology [18])?

3.4 Representation of Self

Perhaps the most interesting research questions of all revolve around the issues of what it means to create an electronic "self" and why users would be motivated to present themselves in this way. The notion of 'self' and 'self presentation' raises many philosophical and psychological issues and represents an extensive research area in its own right.

Research in social psychology [10] can help us to understand when users would want to create autonomous animated representations of themselves, given the amount of effort required. People are motivated to self-presentation when the impressions that others might form of them are relevant to goals that are important to them, and there is a discrepancy between the impression they desire and the image that they think others have of them. The most important factor in the issue of goal-relevance is the degree of exposure one expects from their self-presentation—an area in which the Internet provides greater opportunity than almost any other venue. Business and personal career goals tend to be very important, indicating that such representatives may play an important role in professional communications. Finally, discrepancies in impression can exist when an individual is improperly stereotyped (e.g., based on their profession) or if they have previously made an undesirable impression on their target audience. An animated representative can convey many modalities of self-presentation that are otherwise difficult or impossible over the Internet, including emotional expression, gestures and movement, physical appearance (clothing, hairstyle, etc.), and physical environment (sets, props and lighting).

¹ For example, a quick survey of 200 personal web pages at 5 different sites showed that 55% displayed a photo of the author.

Our current research agenda takes a pragmatic approach to self representation, focusing on the research literature from three related disciplines in psychology: personality traits, nonverbal behavior, and social intelligence. These enable us to consider the explicit and tacit communicative behaviors which are essential for a personal representative. Personality traits are a set of descriptions upon which an individual may anchor themselves or be profiled via personality tests. From these we determine fairly coarse grained design options for personal representatives. Nonverbal behavior is a detailed field of study with consistent and reliable behavioral descriptions across eight to ten categories of behavior (e.g., facial expression, body posture), and is considered to carry from 60-90% of the information in the verbal message being conveyed [9]. From this literature we are able to consider at a finer grain which non-verbal behaviors must be supported by our authoring system to enhance the delivery of information by the personal representative. Finally, social intelligence refers to the ability to present oneself (either through dress, behavior, mannerisms, etc.) in a way that is socially pleasing and well received by others. Our current research involves the integration of behavioral rules derived from these disciplines into the behavioral repertoire of the autonomous characters.

3.5 End-User Authoring

End-user authoring, while tangential to the usage and architectural issues of autonomous personal representatives, is crucially important if we expect these systems to be used by anyone except for programmers. Although some research on end-user authoring of synthetic character behavior has been carried out [3],[17], there is little research regarding the unique authoring goals that we are confronted with here: enabling an author to not only guide the sequence of behaviors needed to convey their intended message but also to deliver that message in much the same manner as they would in real life.

Specifically, we are concerned with two levels of behavioral authoring. The first level includes basic motor behaviors (i.e., moving from point X to point Y), gestures and facial expressions. These activities are general to all users. The second level of behavioral authoring clearly requires finer grained design decisions on the part of end users and therefore is a more difficult problem with respect to the authoring tools required. This level involves the individuation of personal representatives, that is, the ability to express the subtle individual differences that uniquely define the author. Ideally, an identical sequence of behaviors performed by two different personal representatives should reflect the individual differences found in their authors. For example, a simple walk across the screen by an individual who is more formal and dominant will be vastly different than a walk by a individual who has a more casual and relaxed attitude.

3.6 Summary

In summary, we feel that the next generation of personal representatives should:

- Represent their author's interests to others and act on their behalf.
- Present the likeness of their author and use the metaphor of human face-to-face communication when interacting with users;
- Be autonomous, in that they operate without the direct control of their authors, operate opportunistically and reactively, and have their own goals and motivations (as defined by their authors).
- Be easily authorable.

4. APPLICATION: DOCUMENT AVATARS

To gauge the acceptance of animated autonomous personal representatives in the workplace, we have constructed a prototype system in which users can easily author representatives and attach them to documents in order to express their personal opinions about the document's contents. One of the motivations for this particular application is the fact that an individual can often present an idea in a 10-minute personal presentation that would otherwise take pages of formal documentation to describe. Also, attaching a representative to a document restricts the representative's domain of discourse to the subject matter of the document, providing a context in which it can exhibit complex behavior while still being authorable in a short period of time.

These "Document Avatars" can be interacted with by readers of the document in several ways to obtain the opinions of or explanations about parts of the document, or to get guided tours through the document. Other research projects which have investigated automated presentation of document contents include the PPP Persona project [1] and Jack Presenter [14] (neither of which addressed authorability of characters in the user's likeness), and the Active Paths system [27] (which did not utilize a synthetic character).

The system also allows multiple representatives to be attached to a single document to provide the points of view of multiple authors (e.g., in a collaborative effort). This provides functionality which is similar to that provided by the Magic Lens system [20], in that multiple views onto a single document are supported.

Although the behavior of these representatives is currently scripted, we feel that we can learn important lessons from the feedback we get in using this system to inform our design of an action selection engine which produces truly autonomous behavior while providing the proper level of end-user authorability.

4.1 Representation

Document avatars are created in three parts; their visual appearance, their behavior, and recorded audio files. We felt that recorded audio was superior to synthesized speech both in overall quality, and that it aided in the personalization of the representative avatars.

The system uses 2D rendering for avatar animation using warp-able polygons [22]. In this approach, an avatar consists of an arbitrary number of polygons of arbitrary complexity, color, fill, and layering. Each polygon can be attached to one or more control points, which change the shape of the attached polygons when moved during rendering. A “pose” consists of a named set of locations for some number of control points. Run-time animation is achieved primarily by interpolating between poses over specified time intervals. Several poses can be executed simultaneously, giving an avatar the ability to “smile,” “point,” and “walk” at the same time, for example. This approach to animation was selected because it simplifies end-user authoring and provides a run-time animation engine which is computationally efficient.

The visual appearance of an avatar is created in the Avatar Studio, shown in Figure 4. This allows users to construct polygon-based avatars in a “MacDraw”-like environment. The novel feature of this tool is the ability for authors to import a digital photograph of themselves, which is made semi-transparent and overlaid onto the drawing area. This allows them to simply trace polygons over the image to very quickly and easily construct their avatar. The output of the Studio is a compact text representation of the polygons, control points, and poses which comprise the visual appearance of an avatar.

4.2 Behavior

The behavior of an avatar is specified in a scripting language. Each script defines a named behavior which consists of a set of sub-behaviors and/or primitive commands, each of which has an explicit start time (relative to the start of the script) and duration. Primitives include those for performing pre-defined poses, moving, scaling, and playing pre-recording audio files. Thus, an avatar author can create an avatar which “talks” (using their recorded voice) and uses facial expressions, gestures, and body posture (using pose primitives) all simultaneously to produce a narrative about an object in a document by creating a script with the appropriate commands.

One novel aspect of the scripting language is a set of primitives which allow an avatar to simulate user mouse-clicks on document objects, thus enabling it to give a guided tour through a series of hypertext-linked pages (e.g., for a presentation). These primitives all reference a named object on the document (e.g., in HTML the name is that defined in the standard NAME property of the ‘A’ tag). These primitives are:

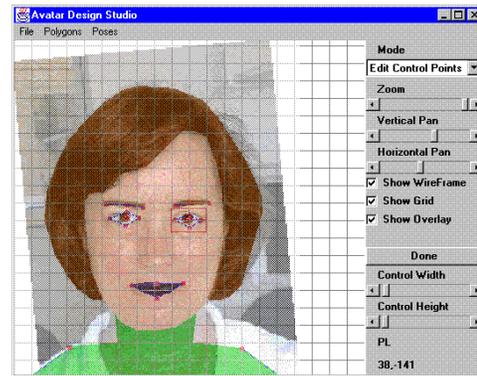


Figure 4. Avatar Authoring Studio

- MOVE_TOWARDS “object”—causes the avatar to be moved into the vicinity of the object on the page, such that it can reach the object with a hand through performance of a pre-defined pose.
- POINT_TOWARDS “object”—causes the avatar to perform one of its pre-defined poses, so that at completion its hand is on or pointing towards the specified object.
- CLICK “object”—performs the same actions as if the user had clicked on the specified object with the mouse. Accompanied by an audible “click” sound.

All of the scripts for a given avatar (pertaining to a particular document) are bundled into a compact text file, together with a reference to the file containing the definitions of the avatar’s appearance. These two files are loaded from the document server for every avatar associated with a document, at the time the document is loaded by the rendering engine.

4.3 Avatar-Document Binding

The Document Avatars system works in conjunction with a hypertext document rendering system, such as an HTML web browser, which supports annotating objects on the page (e.g., word, sentence, paragraph, etc.) with hypertext links, symbolic names, and other properties. Avatars are attached to such a document by specifying a special “Avatar Reference” property associated with a page object (for example, in HTML this is accomplished by adding an “AREF” property to the ‘A’ tag), whose value is a list of pairs, each of which specifies an avatar description file and a behavior specified within that file. This mechanism is normally used to associate comments or narratives about the annotated object by the person represented by the specified avatar.

4.4 User Interaction

When a document is viewed, all avatars associated with the current page are loaded and displayed “docked” in the margin of the document, as shown in Figure 5. Avatar links (as defined above) are highlighted in a color different from that used for regular hypertext links.

Only the heads of avatars are shown while docked to allow multiple avatars to be displayed. Normally, when an avatar is performing a behavior it will appear on top of the document with its entire head and body rendered, as shown in Figure 6.

The user can interact with the avatars in various ways:

- If the user clicks on an avatar link, the behavior associated with the link is performed for the specified avatar. If necessary, the avatar is moved from the margin to the general location of the annotated object, and the avatar's body is rendered, prior to the

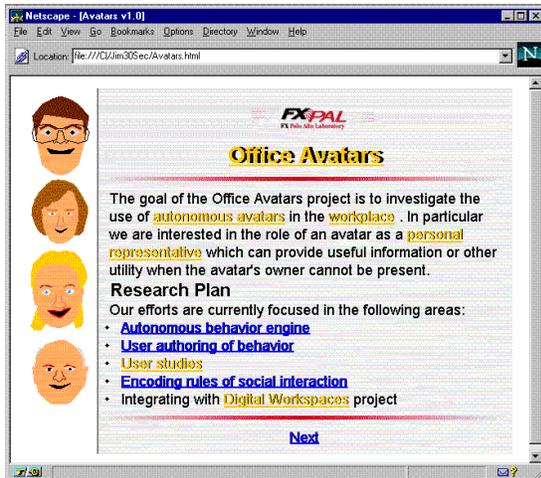


Figure 5. Document with Docked Avatars

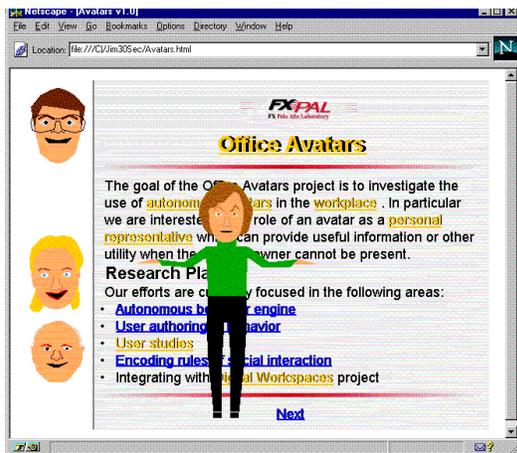


Figure 6. Avatar Performing a Behavior

performance's beginning.

- If the user clicks on a docked avatar it will perform an "INTRO" behavior (typically an introduction or greeting).

- If the user drags the avatar from the margin onto the document it will perform a "SELECTED" behavior, if defined (typically an expression of interest).
- If the user drags the avatar over a document object for which the avatar has a behavior defined, it will perform a "DRAG_HANDLE" behavior, if defined (typically a "happy" expression).
- If the user drags the avatar over a part of the document for which the avatar does not have any behaviors defined, it will perform a "DRAG_NOHANDLE" behavior, if defined (typically a "sad" or "neutral" expression).
- If the user drags the avatar over a document object for which the avatar has a behavior defined, and releases the mouse button, the avatar will perform the associated behavior.
- If the avatar is left on the document following completion of a behavior performance, the document rendering engine will periodically cause the avatar to perform an "IDLE" behavior, if defined.

4.5 Summary

The Document Avatars application has been implemented as a Java applet and allows HTML web pages to be annotated with characters which can be interacted with via any Java-enabled web browser. The Avatar Authoring Studio has been implemented as a stand-alone Java application.

Although the application appears to be very similar to the Microsoft Agent [13], the two projects have very different goals and uses; Microsoft is more focused on providing high-fidelity characters as a generic OS service, and we have been more focused on user representation and character authorability. We can create a 2D character for an individual in 20 minutes, and the specification file is typically 20KB in size, enabling new characters to be quickly downloaded. In contrast, the Microsoft Agent characters are bit-mapped, requiring each frame of any animation to be hand painted, and the resulting specification files are over 3MB. As a result, most sites using their technology use one of Microsoft's pre-defined characters rather than defining their own.

4.6 Lessons Learned

Initial explorations suggest there are a number of general benefits to be gained using these autonomous representatives to augment documents in this way:

- Using such representatives increases the amount of information stored within a document by offering extra information when the avatar is invoked.
- This extra information does not require the viewer to leave the current page they are viewing. The user can

continue to view the current page while being offered more information visually and auditorally.

- The hypertext links in the page can be ordered into a meaningful sequence by the avatar, thus offering strategies for information navigation.
- The avatar can provide a presentation which is custom-tailored to each user's needs, thus making it far more flexible than video clips or other "canned" multi-media presentations.
- In the case in which the avatar creator is also the document author, the avatar can add to the information available by providing the context of the document's construction.

Other explorations of our document-based representatives have included more public appearances in the form of participation in several presentations. In this context, seminar speakers have co-presented seminars with their autonomous personal representatives. By placing the representative on appropriate places within a projected web page, the representative is able to deliver parts of the presentation (see Figure 7).

Informal discussions after these presentations have yielded considerable positive feedback from audience members. A number of studies are planned to further investigate the potential of these autonomous representatives in such settings.

One of the major research issues in extending this system is, of course, how to move from scripted behavior to autonomous behavior on the part of the representatives. Based on our experience in developing both cognitive

problem is how to achieve autonomy while still providing the proper level of end-user authorability.

5. CONCLUSIONS

In this paper we have described the research goals and issues in constructing autonomous personal representatives, and an initial application in which such representatives can be used as document annotations.

We have several user studies planned to assess the effectiveness of such autonomous personal representatives in professional work environments. The first is to consider whether communication through these representatives aids information provision and sharing. Secondly, and at a more social psychological level, the planned studies are aimed at considering how compelling these personal representatives are and whether they have a role for building and supporting interpersonal communication and promoting trust and camaraderie, rather than leaving individuals further isolated behind a wall of mediated interaction [5][6].

6. ACKNOWLEDGEMENTS

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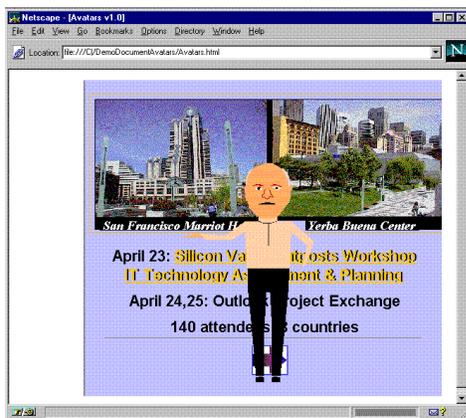


Figure 7. Example Avatar Presentation

model autonomous systems [24] and behavior based autonomous systems,² our opinion is that the most difficult

² In the Autonomous Control Logic program at Lockheed we developed a fully-operational control system for an unmanned submersible.

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Stats (yes/no)

MIT Media Lab: 61 37

PeoplePlace/U.S. 5 4

WhoWhere 32 34

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<http://www.boutell.com/birthday.cgi/> 15 18