Tableau Machine: An Alien Presence in the Home

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CHI 2006, April 22–27, 2006, Montreal, Québec, Canada.
ACM 1-59593-298-4/06/0004.

Abstract
We present *Tableau Machine*, a non-human social actor for the home. The machine senses, interprets and reports abstract qualities of human activity through the language of visual art. The goal of the machine is to serve as a strange mirror of everyday life, open unusual viewpoints and generate engaging and long lasting conversations and reflections. We introduce new models for sensing, interpreting, and reporting human activity and we describe results of our formative evaluation which suggest reflection and social engagement among participants.

Keywords
Affective interfaces, human factors, social experiences, design framework, computational models

ACM Classification Keywords
H.5.2 [User Interfaces]: Prototyping; Theory and Methods; User-Centered Design – Affective Interaction.

Introduction
Research in ubiquitous computing (UbiComp) and Ambient Intelligence (Ami) seeks to build systems that are enmeshed in the world and imbued with proactive intelligence. However, much of this work remains rooted in an information access and task-support

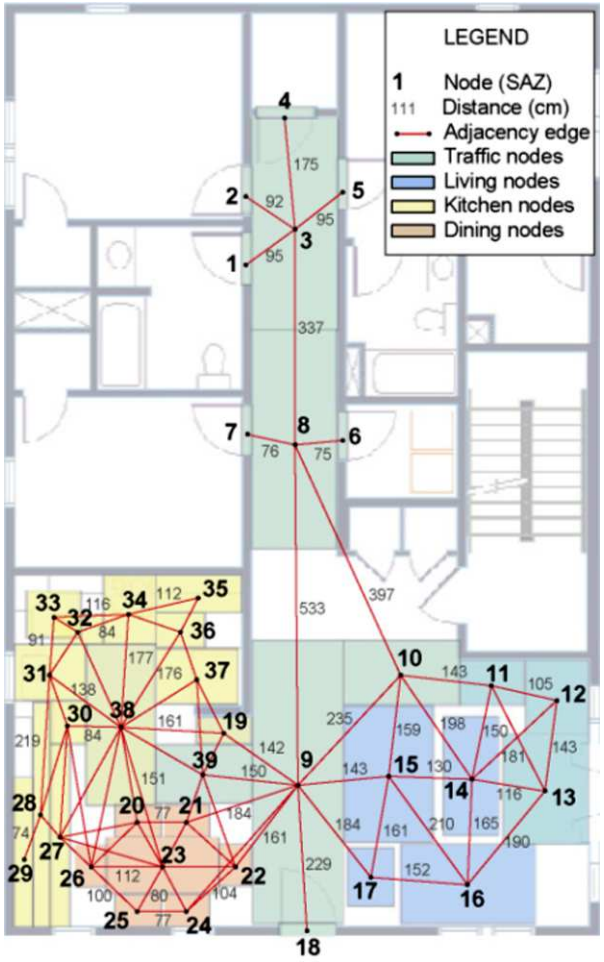

Figure 1. Floor plan of the Aware Home overlaid with the adjacency graph of the 39 semantic activity zones. Activity is sensed with overhead cameras.

model, in which the goal is to optimize human performance. We present an alternative objective, where the goal is long term active reflection on everyday activity, enjoyment and pleasure. We have built and formatively evaluated a non-human social actor for the home, the Tableau Machine. We refer to this model of non-human social actor as Alien Presence [2]. An alien presence is a computational actor in an everyday human environment. It senses and interprets abstract qualities of social activity in the environment and it reports back to the people it observes through the language of art. An alien presence does not try to mimic human perception and interpretation, but rather to open a non-human, alien perspective onto everyday activity. The machine uses computer vision to sense, numerical AI techniques to interpret, and autonomously generated 2D graphics displayed on a 42'' plasma screen to interact. The goal is to encourage engaging conversations and reflections by opening unusual viewpoints into everyday life. We present our model of an alien perception, interpretation and rendering system and its formative evaluation.

Perception

We have installed the Tableau Machine at the Georgia Institute of Technology's Aware Home [1]. We use the vision system of the home: 10 overhead cameras dispersed over the social areas. We divide the space of the home into socially meaningful sub-regions labeled semantic activity zones (SAZ). We group the regions by the place in the home they belong to, for example living room, or kitchen. We also define a topological relationship of adjacency between the zones. (See figure 1).

We observe activity as the accumulation of motion over a period of time and within a SAZ. We do not track or recognize people. We simply log movement. When

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aggregating motion over a temporal window of a few seconds, most human activities generate perceptible motion. Even activities not considered physical, like reading or watching television, generate motion by their "fidgeting factor".

Interpretation

We are interested in the character of human activity. Are people busy, hurrying, socializing, relaxing, together, or apart? By sensing the time and place of aggregated motion we can characterize human activity. We call this approach *activity characterization*. Unlike activity recognition, where the goal is to determine the concrete nature of actions such as "washing dishes" or "eating dinner", activity characterization seeks to determine the mood of the environment.

The goal of the interpretation system is to characterize human activity from an alien perspective. We have created three proxy measures to characterize social activity: *social energy*, *social density* and *social flow*.

Social energy

We define social energy as the accumulation of motion over socially meaningful temporal and spatial sub-regions of the home. The temporal and spatial windows are design parameters. A perfect temporal window varies depending on the character of the activity. High energy activities, where there is a lot of motion, should have smaller temporal windows and vice versa. We also use the temporal window as the design parameter that controls the refresh rate of the visual display. In practice we have used a fixed refresh rate of 1 to 5 minutes.

The perfect spatial window also varies. The social nature of space is dynamic, thus some activities group zones together while other activities do not. A detailed study of the habits of a home is necessary to determine the dynamic nature of sub-regions of space. In practice we have used individual SAZs, groups of zones in delimited places of the home, such as the kitchen and the dining room, and the entire house as a single environment.

In figure 2 we show matrix display of how motion accumulates in different places at different times during a social night at the aware home. The rows are the SAZs and the columns are the seconds. By aggregating the elements of a sub-matrix we determine its social energy. Once the sub-matrix is fixed by the designer, the system runs fully autonomously. A future exploration is dynamic spatio-temporal resolutions.

Social Density

We define social density as the number of active zones divided by the volume the zones occupy. We measure volume as the distance between the active zones, namely, as the length of the minimum weighted spanning tree connecting the active nodes over the adjacency graph.

In figure 2 some activities are visually denser than others. For example, "playing Cranium™" is denser than "cooking".

Social Flow

We define social flow as the change of activity between adjacent zones. It does not necessarily correspond to physical flow. Social flow can be the product, for example, of conversational turn taking and gesturing.

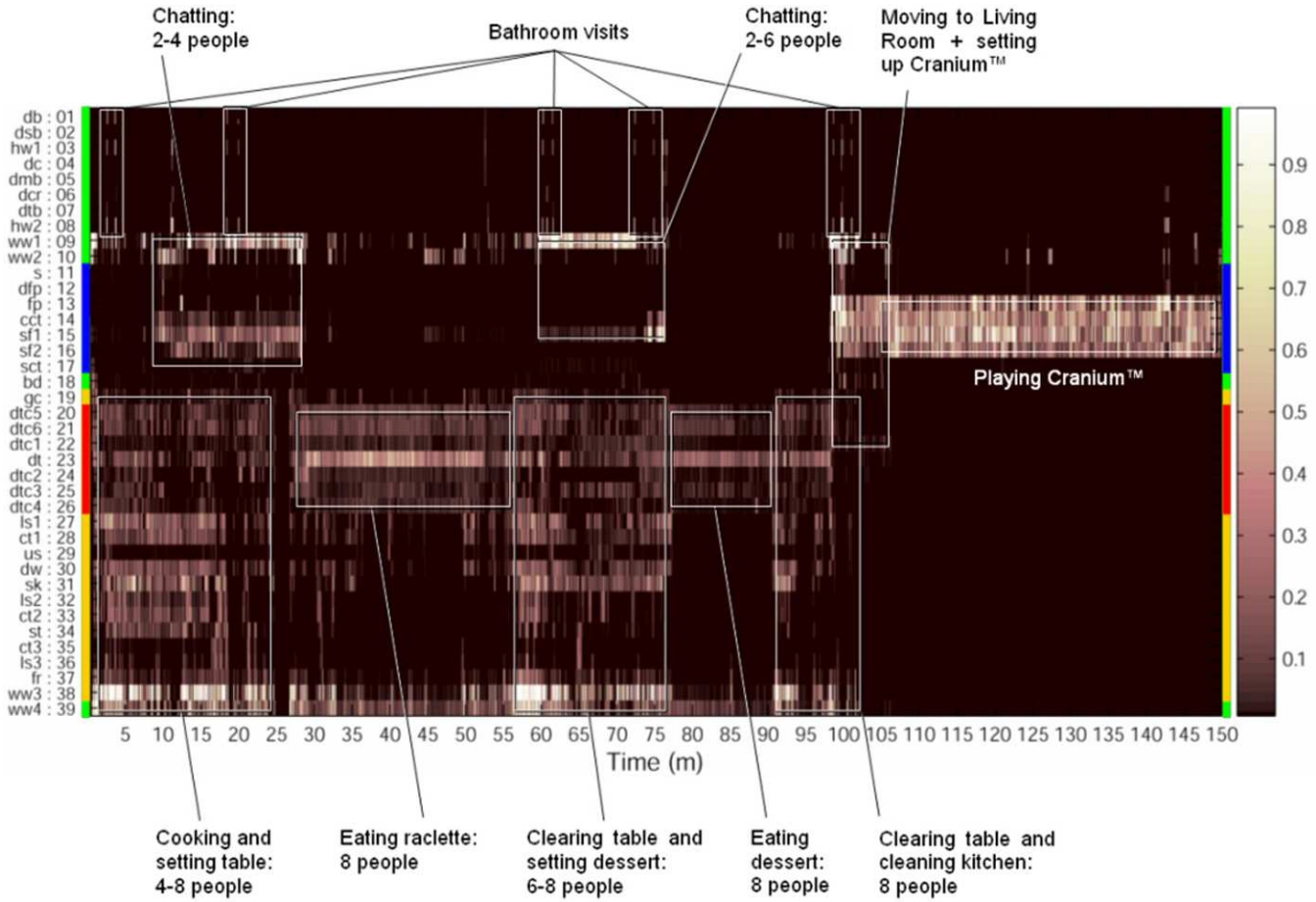
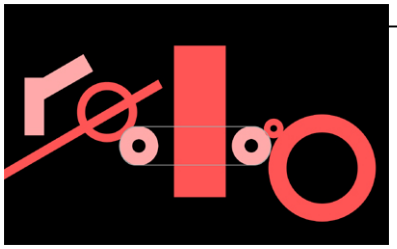


Figure 2. Visualization of the amount of motion during 150 minutes of a social night over time and over the semantic activity zones. The columns represent time. The rows represent the 39 semantic activity zones. Activity is sensed as motion by the overhead cameras and it is accumulated over the zones. The highest activities map to white; the lowest, to black. The visualization shows activities as they are located in space and time. The activities have been annotated by hand. The zones are color coded according to the sub-region of the house to which they belong. Traffic zones are green. Living room zones are blue. Kitchen zones are yellow. Dining room zones are red.



Production of the Tableau Machine. In this production the machine interprets high social density in one part of the home.

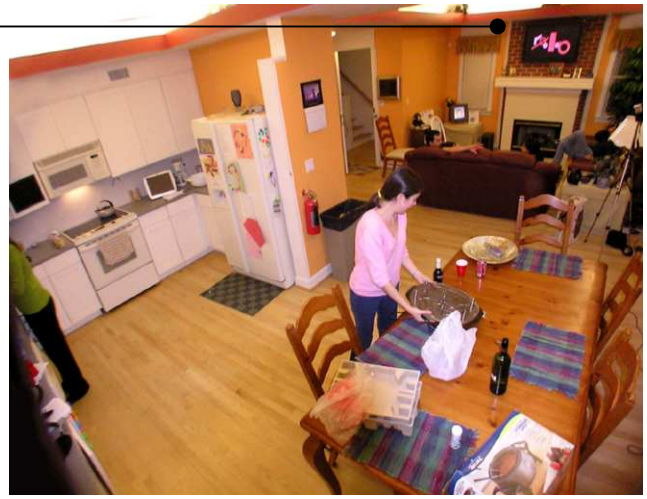


Figure 3. The figure shows a moment during the formative evaluation of the Tableau Machine in the Aware Home. It is a social night with six participants. On the upper right corner there is a production of the Tableau Machine displayed on a plasma screen hung over the fireplace.

Interaction

Tableau Machine interacts with users through a 42'' plasma screen over the fire place in the living room of the aware home. The language of interaction is abstract visual compositions, a purposefully ambiguous language. An alien presence should be amenable to an intentional interpretation (interpretation as an intentional actor). Further, the display should have enough ambiguity that it allows viewers to engage in co-interpretation, projecting their own meanings onto the display. Thus we require that the mappings between what the machine senses and interprets and what it reports are not simple one-to-one mappings, but rather involve a more complex chain of interpretation and generation between sensing and display. Abstract visual composition provides a connotatively powerful language for conveying social mood while being ambiguous enough to support co-interpretation. A potential danger with complex mappings is that they become indistinguishable from randomness, and thus frustrate viewers. Simple mappings will not give evidence of intention. The machine would not hold interest for long. We seek to find the "sweet spot" in this complexity continuum, in which the machine is amenable to intentional interpretation and supports long-term engagement.

For this version of Tableau Machine, we used a set of hand made productions that we considered conveyed different combinations of energy, density and flow. The sensing and interpreting system provides the production system with an energy-density-flow triplet, from where the production system simply picks the appropriate rendering. The next iteration of Tableau Machine will include an autonomous generative art production module.

Formative evaluation

We held a six participant focus group at the Aware Home. We recorded the participants, both with the system and with a tripod-mounted video camera during a scripted evening of normal household activities. The participants prepared and cooked a dinner, cleaned up, and retired to the living room for dessert. Tableau Machine was active for the duration of the evening (see figure 3). We concluded with a one hour discussion of

the system, participant's reactions, and their suggestions and recommendations for improvement. The evaluation lasted four and a half hours in total.

The experimenters explained to participants how the system functioned in vague terms, and showed the ceiling mounted video cameras, as well as the large plasma display. During the debrief section, the experimenters answered questions about what the system was sensing, and further gave information on the space and number of productions.

The machine elicited engagement and discussion, without any prompting other than the system introduction. Participants glanced up at the display quite frequently, reviewing its state as they went about their household tasks.

Participants made comments such as "Ooooh, cool!" and "Look at that!" as they saw subjectively interesting collages, and they shared these with other participants using their statements and gestures. They discussed the system as having internal states, starting their statements to one another with "It thinks…" or "It just did…" They also came to the conclusion that the system was a type of mirror, though they did not immediately grasp exactly what aspects of activity the system was mirroring. They did not find the active compositions active enough, or the more passive compositions passive enough. Participants also attempted to influence the machine by purposefully hiding from the view of the cameras or effusively moving under the cameras. Finally, the participants stated that the system needs to produce compositions more frequently. The temporal window was set at 5 minutes.

Conclusions and future work

With Tableau Machine we have introduced new sensing and interpretation algorithms. Furthermore, we have begun the exploration of new interaction paradigms, where the goal is long term social engagement and reflection on everyday activity. We are currently developing the next version of the machine, which will have an autonomous generative art module and improvements in activity characterization. We are also developing new design and evaluation methodologies. Our future work includes a longitudinal in-situ evaluation of the machine in a real home.

Acknowledgements

This research has been supported in part by a grant from the National Science Foundation, IIS-0534355. We also thank the evaluation participants for their time and valuable feedback.

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