Ligature: Gesture-Based Configuration of the E21 Intelligent Environment

Mark A. Foltz*, Luke Weisman†, and Krzysztof Gajos†

* Design Rationale Group, `http://www.ai.mit.edu/projects/drg/`
† Intelligent Room Project, `http://www.ai.mit.edu/projects/iroom/`

The Problem: Intelligent environments (IEs) have enormous potential for creating collaborative spaces that support and enhance natural human interaction. However, user-level configuration of the complex technologies underlying IEs remains an HCI challenge. Ideally, the user interface should (1) show useful information about the current state of the IE, especially when that state is hidden in computational agents; and (2) hide unnecessary details of the technology controlling the IE.

To address these issues we have developed Ligature, a user interface that supports the configuration of the E21 Intelligent Room. Ligature shows the user a map of video sources and displays in the Room and allows her to change how they are connected with pen gestures, as in Figure 1. Ligature works together with Metaglue, the multiagent software system for the Intelligent Room, to hide the complexities of device control, resource management, and other technical details of the IE from the user [2].

Motivation: Users of the Intelligent Room often wish to configure the video projectors in the Room to support their activity. For example, showing a movie requires only the end-wall projector, while an intense work session requires all of the displays. Previously, video connections could be made by several means: voice commands, manual control (i.e., pressing a button in an adjacent room), or an HTML form interface. However, these methods do not show where displays are located or how they are currently connected. Also, users cannot save a configuration for later use.

We believe Ligature overcomes these limitations. The user can easily see the current video connections in the Room on Ligature's overhead map. A connection can be created or removed with a single pen stroke on the map, providing a consistent, direct-manipulation interface. And, the current set of connections can be saved and later recalled, to preserve useful configurations of the Room.

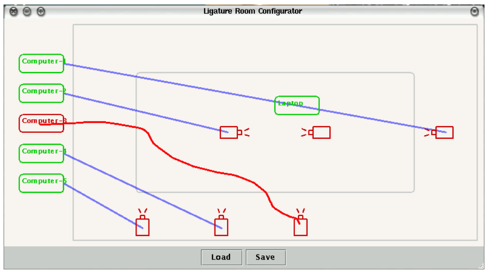

Figure 1: Ligature shows the user a map of devices and connections in the Intelligent Room. Users can draw new connections on the map (the wavy line).

Previous and Related Work: The Intentional Naming System (INS) maps a user intention (i.e., "print this to the nearest printer") to the network location of services and resources which fulfill that goal. [1]. Such indirection is one key to hiding the complexity of ubiquitous and mobile computing environments from their users. In the same spirit Ligature makes use of the Metaglue `Translation` agent to provide meaningful names for devices on its map (see below).

The Open Agent Architecture is a multiagent software system that supports multimodal input (keyboard, speech, and pen gestures) [4]. Inputs from the modalities are interpreted into a standard logical form and passed on to applications. While both Ligature and OAA make use of gestural input, OAA is not specifically designed to be embedded within an IE.

Approach: Ligature currently supports three gestures. Selection is performed by tapping a device on the map to highlight it. Devices which can be connected to the selected device are also highlighted. A connection is made by drawing a stroke from one device to another. If the devices are compatible, Ligature requests a new connection and updates the display. Other devices may be disconnected according to the constraints enforced by Rascal, the resource manager for the Room [3]. Devices are manually disconnected by drawing a short stroke that crosses an existing connection.

Ligature interacts with the IE solely through three other agents in the Metaglue system. Ligature uses the `Translator` agent to find connectable devices in the IE, and to look up human-readable names to annotate its map. Ligature queries the `Geometry` agent for the shape, size, and location of agents representing connectable devices such as a computers or projectors. Ligature uses the `ConnectionMaker` agent to add or remove actual connections via muxes and switches. Ligature is also notified by the `ConnectionMaker` of changes to connections, so it can maintain an updated map of connections.

Ligature obtains all its knowledge of the IE solely through these agents, and so adapts itself to dynamic changes in the environment. Consequently, Ligature is portable to other IEs besides the Intelligent Room. The above agents were developed independently of Ligature, and Ligature was later built on top of them. In fact, many other applications use these same agents for their own tasks.

Impact: Ligature has been implemented and is available for day-to-day use in the Intelligent Room. It currently supports the interconnection of the video sources and displays in the Room.

Ligature has also tested the adaptability and accessibility of the Metaglue infrastructure. The Ligature UI was first developed and refined independently, and later integrated with Metaglue. We did not encounter significant difficulties during this process, and were happy to verify that Metaglue is a flexible and expressive infrastructure that an engineer can use to easily build complex and novel IE applications. We would like to encourage our colleagues to brainstorm new applications and interfaces for the Intelligent Room; Ligature demonstrates that Metaglue provides a functional software environment for bringing your ideas to life!

Future Work: We plan to evaluate the usability of Ligature by asking volunteers to perform basic tasks with the interface. Usability questions to be addressed include:

- What are a natural set of gestures for device management? When making a connection, users may want to draw lines or arrows, or circle the endpoints. Ligature should support all these gestures, or guide the user to a specific set if recognition becomes too difficult.
- What are natural ways that users indicate items on the map? For example, some may prefer to indicate a display surface, while others prefer to indicate the projector that creates the image.

We also plan to raise the level of abstraction at which Ligature operates. In the end, we feel that users care little about system-oriented concepts like *devices* and *agents*, but much more about goal-oriented concepts like *workspaces* and *projects*. A long-term goal of Ligature is to bridge the gap between users' goals and the technology of intelligent environments, perhaps by combining speech and gesture, i.e. "Keep this project where I can see it when I am working."

Research Support: This research is sponsored by MIT Project Oxygen and the MIT Ford Motor Company Collaboration.

References:

[1] William Adjie-Winoto, Elliot Schwartz, Hari Balakrishnan, and Jeremy Lilley. The design and implementation of an intentional naming system. In *Proceedings of 17th ACM Symposium on Operating Systems Principles (SOSP 99)*, pages 186–201, Kiawah Island, SC, December 1999.

[2] Michael Coen et al. Meeting the computational needs of intelligent environments: The Metaglue system. In *Proceedings of MANSE'99*, 1999.

[3] Krzysztof Gajos. Rascal - a resource manager for multi agent systems in smart spaces. In *Proceedings of the Second International Workshop of Central and Eastern Europe on Multi-Agent Systems (CEEMAS 2001)*, Cracow, Poland, September 2001. To appear.

[4] Douglas B. Moran et al. Multimodal user interfaces in the Open Agent Architecture. In *Proceedings of Intelligent User Interfaces (IUI) 1997*, Orlando, FL, 1997.