GURU: A Multimedia Distance-Learning Framework for Users with Disabilities

Vidhya Balasubramanian & Nalini Venkatasubramanian
Dept. of Information & Computer Science
University of California, Irvine, CA 92697-3425
Irvine, CA 92697-3425, USA
{vbalasub,nalini}@ics.uci.edu

ABSTRACT

GURU is a distance-learning environment that renders multimedia information to users with disabilities in an accessible manner. It is an implementation framework developed as part of an effort to provide accessible multimedia information to end users with perceptual (visual and auditory), cognitive or motor impairments. GURU is based on the MPEG-4 standard, and it modifies MP4 content and the presentation of the different objects in the scene dynamically based on users' visual, auditory and motor abilities. This paper briefly describes the implementation of the prototype framework and illustrates sample adaptations as implemented in this framework.

Categories and Subject Descriptors

H.4 [**Information Systems Applications**]: Miscellaneous

General Terms

Design, Human Factors

Keywords

Accessibility, Adaptation, Multimedia, MPEG-4, Distance-Learning

Recent trends in ubiquitous computing focuses on providing information embellished with multimedia data to users anywhere and anytime. While applications like distance learning represent unprecedented opportunities, it is also essential to ensure that the resulting benefits also enrich the lives of the disabled, and the elderly, by making information more accessible. To ensure the utility of the distance-learning application, the underlying infrastructure must adapt the information and the learning environment appropriately so that it is easily accessible to users with disabilities. A major step in the realization of accessibility is that of an adaptation framework that can modify information according to users' ability (disability) requirements. Using an MPEG-4 based distance-learning framework, we demonstrate how to enhance the quality of the distance-learning portal by changing resolution, color levels, audio quality, the layout of the different objects in a scene etc. The following sections will briefly describe the architecture of GURU, outline of the adaptation policies and the demonstration environment.

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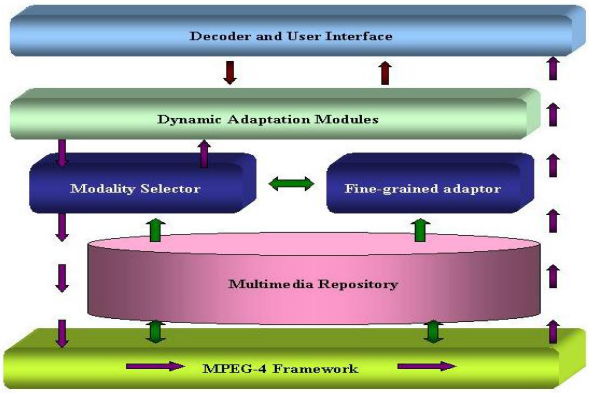

Figure 1: Architecture of GURU

1. THE GURU ARCHITECTURE

The GURU framework dynamically modifies multimedia information for users with vision impairments, auditory impairments and upper body motor impairments. Adaptation of multimedia information is done in two levels - 1) An initial content selection process which selects the best version of the multimedia content from a multimedia repository, for the given user profile and 2) Fine-grained adaptation process which performs actual content modification on the selected content like contrast enhancement, etc. Algorithms for content selection and fine grained adaptations are being developed as part of the efforts in providing accessible multimedia information [4].

The architecture of the GURU framework is described in Figure 1. It consists of the following main components. In this demo all these components will execute on a single machine.

Multimedia Repository: This is a repository of author generated MPEG-4 content that has to be delivered to the user. Different versions of the content are stored in this repository. The repository also stores meta-data information that represents the following : 1) An accessibility representation that encodes the utility of each modality (and quality level) to each user class for the given application. 2) Media related information - stores information about the dif-

ferent quality parameters for each media-type (e.g. color, intensity, resolution for images, sampling rate for audio, frame rate for video etc.) 3) Resource requirements of different media types at different quality levels.

Modality Selector: The modality selector selects the most appropriate modalities to be sent to the user based on the ability driven content selection scheme [4].

Fine-Grained Adaptor: The fine-grained adaptor performs adaptations to the selected content using image, video and audio processing techniques and generates adapted versions of the content. The content adaptation can be performed offline or in real-time.

Dynamic Adaptation Modules: These modules identify users requirements on the fly and modify the MPEG-4 stream dynamically. These modules are implemented as MPEG-J API's (MPEG-J API's are java classes built above the MPEG-4 layer [1, 2, 3].

Adaptation Policies: Adaptations for different vision, auditory and motor impairments have been developed and described in our other publications [5, 4]. In order to modify information for users with vision impairments an image processing tool kit is being developed. This modifies the visual information for impairments like refractive errors, glaucoma etc. Auditory impairments include deafness and other impairments like conductive hearing loss, sensory neural hearing loss etc. The audio tool kit supports captioning, and audio processing techniques like filtering, frequency shifting etc. In the context of information access, motor impairments refer to upper body motor impairments that result in tremor, limited movement and strength, thereby affecting interaction with an interface. The interaction is also limited by the degree of freedom of the input device and the complexity of the interface. Improving accessibility for motor impairments will include interface level adaptations, controlling streaming according to users interaction capability and synchronization between modalities.

2. DEMONSTRATION ENVIRONMENT

The prototype of GURU for the demo has been developed using the MPEG-4 framework, with the interactive properties needed for a distance learning environment. Adaptation modules are built into the MPEG-4 stream or designed as JAVA classes which modify the underlying content. In order to enable the MPEG-J API's to perform the adaptations, a parser has been developed to preprocess the MPEG-4 data, by identifying and tagging points of interest like location of objects in a scene, video bit rate etc. To illustrate our adaptation framework we developed a sample distance learning session as shown in Figure 2.

The session includes a video clip of the instructor, an instructional video if needed, a PowerPoint presentation synchronized with the video object and a noteboard which will display the classroom whiteboard. There is a caption of the audio which can be turned on or off. A chapter menu helps navigating between chapters. The adaptation modules will perform the required adaptations on the individual media streams, and create the scene specification for the newer version of the MPEG-4 stream. An initial profiling session is designed to identify user's requirements. Feedback mechanisms are also being built into the interface to dynamically profile the user. After the initial profiling session the content selection mechanism will be performed to transmit the most suitable version of the MP4 file to the user.

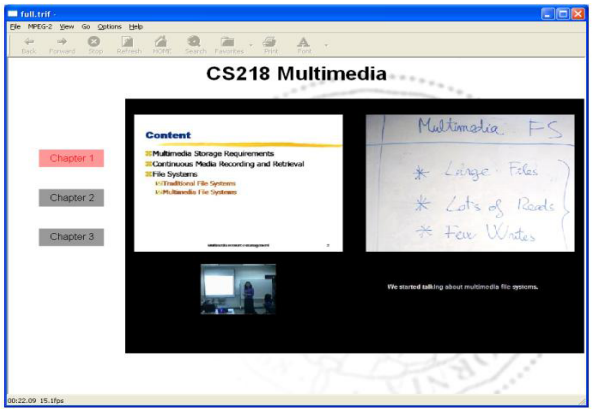

Figure 2: A sample screen shot of GURU

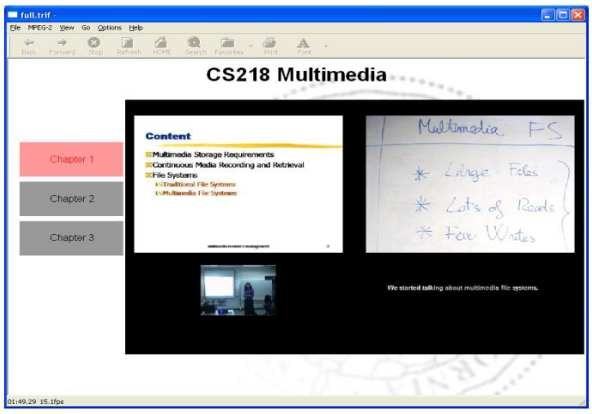

Figure 3: Screenshot demonstrating adaptation for tremor

Experiments will be carried out to demonstrate the adaptations for vision, auditory and motor impairments. While some of the content processing will be performed offline, other adaptations will be performed on the fly (e.g., contrast enhancements, brightness modifications, zooming and interface layout changes). For instance if a user exhibits motor tremor resulting in difficulty clicking buttons or menus, the MPEG-J API's detect this tremor using built in feedback mechanisms in the interface, and modify the size of the menus accordingly as shown in Figure 3. In this sample we can see that the menus are enlarged so that user with tremor will not miss the target. Using experiments like these we will demonstrate the content adaptation techniques to improve the accessibility of multimedia information for users with disabilities.

3. REFERENCES

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