Maintaining Medical Image Annotations in I^2Cnet

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ABSTRACT

I^2Cnet (Image Indexing by Content network) aims to provide services related to the content-based management of images in healthcare over the World-Wide Web. Each I^2C server maintains an autonomous repository of medical images and related information. The annotation service of I^2Cnet allows specialists to interact with the contents of the repository, creating comments or illustrations on groups of medical images. I^2Cnet annotations may be communicated to other users via *e*-mail or be posted to I^2Cnet for inclusion in its database. This paper discusses the annotation service of I^2Cnet and argues that similar services pave the way towards the evolution of active digital medical image libraries.

INTRODUCTION

The World Wide Web (WWW) is currently enjoying rapid growth and increasing popularity due to its visual nature and information retrieval capabilities. This has resulted in substantial research effort being devoted to the development and provision of information services on this new platform. I^2Cnet (Image Indexing by Content network) is part of a research effort for the development of robust content-based retrieval methods for different classes of medical images. I^2Cnet [1] is organized as a network of I^2C servers, which interoperate with Image Management and Communication Systems (IMACS) and offer services related to the content-based management of images (see fig.1). The main requirements of the I^2Cnet architecture are *availability* to authorized users throughout the world, who have access to a typical public domain web browser like Netscape or MS Internet Explorer, *interoperability* with the evolving regional health care network of Crete, and *network transparency* that allows users to request a service by name without being aware of the underlying server infrastructure.

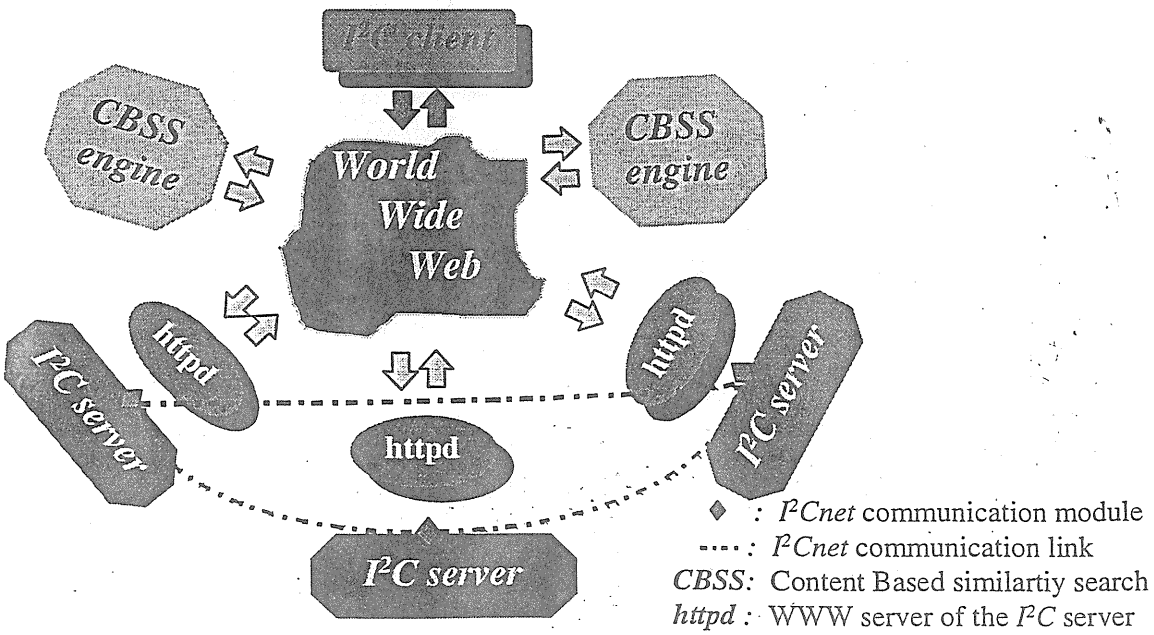

Figure 1: I^2C servers can be accessed from the World-Wide web and cooperate to provide services related to the content-based management of images

This paper discusses the medical image annotation service of *I²Cnet,* focusing on issues related to its functionality, user interface, storage management, and service interoperability. The objective of this service is to provide healthcare professionals with the ability not only to access medical image collections, but also to interact with imagery, creating, viewing, and communicating annotations on groups of images. Specifically, the medical image annotation service of *I²Cnet* allows specialists to create annotations on groups of images, communicate them to any Internet or Intranet user by e-mail, and to search for medical images and/or annotations based on annotation text and image content.

ANNOTATIONS: A WAY TO TALK ABOUT SETS OF IMAGES

An Internet connection provides healthcare professionals at remote locations with the necessary infrastructure to reach the regional healthcare network, get the latest updates in their specialty, read news, contact their peers, access on-line medical journals, or browse medical image collections. *I²Cnet* services also allow them to browse through medical image archives guided by different notions of image similarity. In particular, the medical annotation service of *I²Cnet*, allows the users to interact with information that is mostly static, associating it with dynamic entities, i.e. annotations.

Frequently, a healthcare professional that browses through an image collection wishes to select a few images and create a note, optionally private, pointing out interesting features and comparing these images to images from other collections. Such annotation objects may serve as the basis for communication with other specialists, discussion, and exchange of ideas and opinions. Thus, the annotation service adds a dynamic dimension to the image collection by allowing users to associate annotations that relate image sets to text, graphics, and other forms of medical data. Annotation objects which are created in the context of *I²Cnet*, can be communicated in HTML format, to any Internet or intranet user. Furthermore, the annotation service, when used in combination with the image posting service of *I²Cnet* will allow authorized users to post interesting medical cases as annotations into *I²C* servers. Thus, a digital medical image library will begin to evolve with contributions by healthcare professionals.

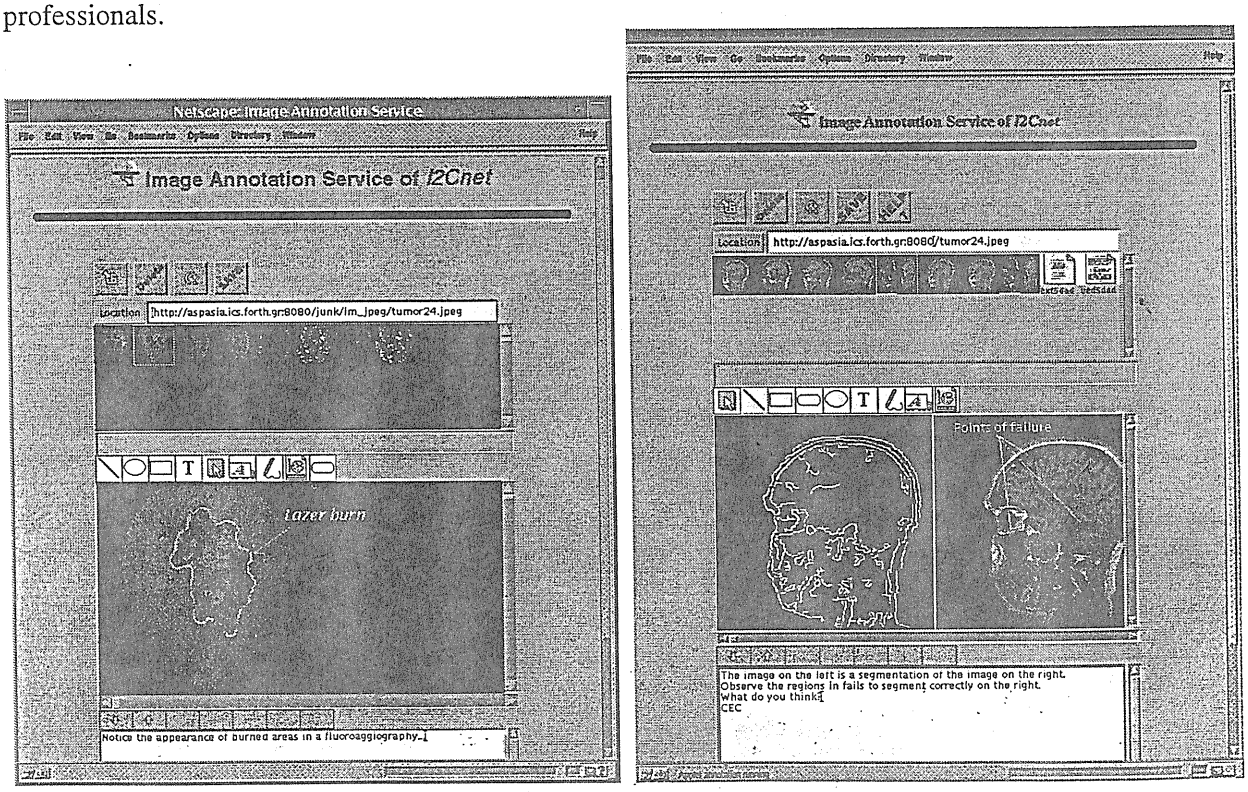

Figure 2: There is a number of annotation types: comment, refutation, confirmation, correction, and illustration to name a few. The screen on the left illustrates a laser burn in a fluoroangiogram. The screen on the right points to areas of an image, where a segmentation algorithm fails to produce good results.

ANNOTATION ENVIRONMENT

Each I^2C server maintains thumbnails, descriptions, and annotations of medical images. Images are organized into high level classes that express medical imaging modalities and parts of the anatomy. By selecting an image class, the user may browse through miniatures of the images that belong to that class.

User Interface

The user interface of an I^2C server is composed of web pages that contain applets specific to the provided service. A temporary workspace is assigned to each user that visits an I^2Cnet site and the contents of the current workspace are displayed on every I^2Cnet page throughout navigation. During exploration, the user may add/remove/preview items from the contents of the workspace. These items may come from the pages currently visited or from any other place in the network. Since the current workspace is mapped onto all user pages during each session, users have all items of current interest readily available.

For each image registered with I^2Cnet, the user may request to view the list of annotations that reference the particular image. Upon selecting an item from this list, the annotation environment displays the selected annotation. The annotation environment consists of a graphical area, toolbars, a text window, and the current workspace. An I^2Cnet annotation on a group of images is composed of images to be annotated, graphical objects (drawings and text), accompanying text, associated objects (audio, video, related annotations, etc). The user may request information on the components of the annotation on display: images, text, and drawings. Information on drawings includes geometric properties, while information on images includes owner, size, origin, type, etc.

When creating an annotation from scratch, a set of one or more images are selected from the virtual workspace to be added to the annotation graphical area. Then, using the set of available drawing tools, the user may add geometrical shapes (lines, rectangles, ovals, etc.), hand-drawn shapes, arrows, and text. Individual shapes may be grouped and treated as a compound object. Each object can be edited, moved, or deleted and its properties can be previewed. In addition to text that may be typed on the graphical area, a separate text window provides space for detailed comments (see fig. 2). The resulting annotation object may be posted to the I^2C server, exported in HTML format, or mailed to other Internet users by e-mail.

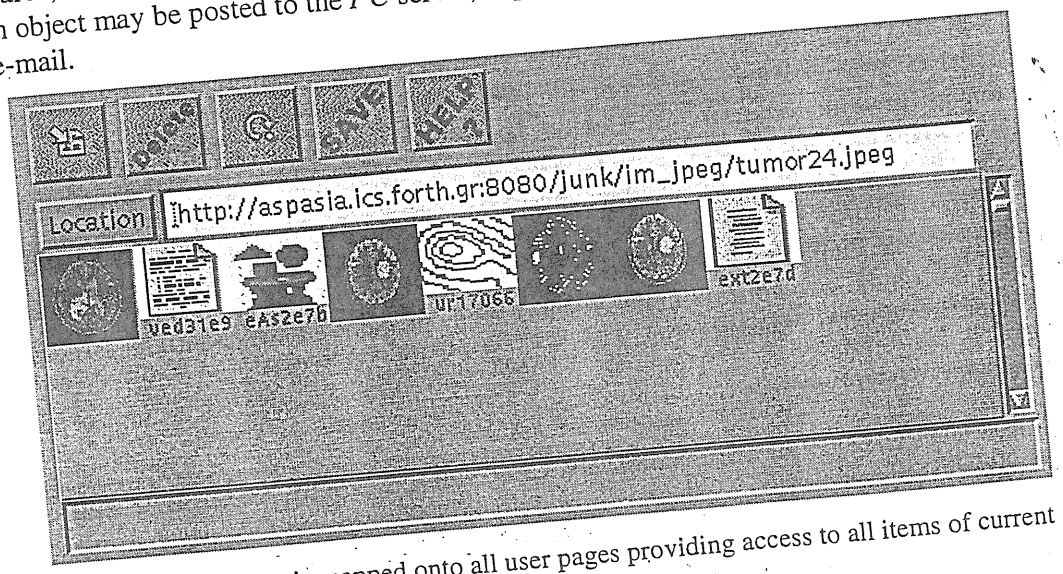

Figure 3: A virtual workspace is mapped onto all user pages providing access to all items of current interest.

Virtual Workspaces

There are various types of virtual workspaces which differ in terms of lifetime, access privileges, and location. Any user may browse through image classes, image thumbnails and their annotations and copy

a selection of images and annotations to a *temporary* workspace. The lifetime of a temporary workspace is short, typically 24 hours. However, authorized users may acquire *personal* workspaces which are password-protected. A personal workspace account can be provided by the administrators of *I²Cnet*, after filling a form with the user name, occupation, post and e-mail address, requested login name and password, and references. In contrast to temporary workspaces, personal workspaces provide long-term persistence to the interaction of a user with *I²Cnet*, since the contents of the workspace persist from one visit to the next.

Both temporary and personal workspaces have a name assigned to them. Multiple users may connect to the same workspace, for the purpose of short-term cooperation. In this case, the workspace operates as a virtual blackboard and provides the basic infrastructure for Computer Supported Cooperate Work (CSCW), since one user may add items to the workspace and these items are immediately visible to other users in the same workspace.

Currently, all workspaces are *server-based*, i.e. located in the disk space of an *I²C* server. However, *client-based* workspaces which reside in the disk space of the user and operate as browser plug-ins, are also being considered.

Storage of annotations

Each *I²Cnet* annotation is stored in ascii format to enable content-based search. Other storage formats like DXF [2] that will enable the portability of *I²C*net annotations across different systems are also being considered. Annotation files consist of references to image objects, drawing objects, and free text. In addition, for each annotation, *I²Cnet* maintains a *properties* object which includes a unique identifier, information on the creator of the annotation object, the time and date of its creation, and the location of the annotation file on the disk.

The textual contents of the annotation are indexed in order to enable fast search through them. The properties of each image object include the list of all annotation objects it belongs to. Every time a new annotation object is posted to an *I²C* server, the properties of all referenced images or associated objects are updated. Thus, a user that requests the list of annotations, always gets up-to-date information.

RELATED WORK

A number of researchers from different disciplines, address the problem of maintaining annotations on the web [3-7]. Reported work concerns mostly document annotations and focuses on groupware activities. The NCSA Mosaic browser supports private user and workgroup annotations on documents by associating URLs with comments [3]. CoNote [4] was a project at Cornell which provided support for annotations in class material. Another system developed in the context of the Stanford digital library project is Commentor [5, 6]. Both CoNote and Commentor address the issues of document and annotation sharing, security, organizing annotation into conversations, searching annotations by content, and annotations referencing other annotations. A good review of issues relevant to the maintenance of public annotations on the web appears in [7]. Even though our work addresses similar issues, it focuses on image rather than document annotations.

CONCLUSIONS - FUTURE WORK

This paper presents the annotation service of *I²Cnet,* which allows users to create annotations on groups of images, and communicate them to other users via e-mail or publish them in *I²Cnet*. Our current work focuses on searching annotations by image and textual content. To search the annotations, the user creates an annotation template, specifying exact or approximate match for the components of the template. We are also considering the introduction of different types of annotations and support for discourse structures.

The integration of the annotation service with the patient record management system of a health telematics regional network and the provision for synchronous communication using the annotation environment, are also being considered.

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