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New Media Art Projects, Panoramic Images and Live Video as Interface between Real and Virtual Worlds

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ABSTRACT

This paper starts with the concept of a virtual gallery where art works, mainly pictures, are presented on the world wide web. One of the first such galleries, the Slovenian Virtual Gallery existing from 1995 is being considered. Today, such galleries are conceptually not much different, however, they typically contain much more material of higher resolution in 2D and 3D. Several open source tools are available for development of such virtual galleries. To gain some notion of immediacy, efforts were made to mix such virtual worlds with live video from actual spaces and locations. A novel user interface was developed using panoramic images of the location where the internet camera is located. The live video image is shown overlaid on the static panoramic image so that when a tele-operator manipulates the camera he gets a much better understanding of the remote location. A new media art installation was produced. First, successfully the concept of the virtual gallery and the live video panoramic interface and later interactive art installations was taken up where video or images were used as primary means of interaction and feedback. Five such art installations are presented; the sixth project shows how this concept can be applied to adaptive digital signage.

Keywords: Virtual gallery, internet video server, panoramic images, Slovenia, CAD

1. INTRODUCTION

This paper gives an overview of work related to art presentation and production of new media in the Computer Vision Laboratory at University of Ljubljana. Here, art-related activities began in the first half of 1995, at the outbreak of the world wide web expansion, when the Slovenian Virtual Gallery (SVG) was developed which was a typical first generation web multimedia presentation consisting of an interconnected set of texts, images, and video clips[1]. An alternative way of exploring this set was by 'walking' through a virtual gallery space. It was a demonstration project to show how Slovenian fine art could be presented on the internet. At that point of time, there were no tools yet for such website design, own tools were developed. Now, there are several open source tools available for building such web presentations.

"When SVG was presented in the fall of 1995 at Infos, the annual information technology trade fair in Ljubljana, I met Srečo Dragan, Professor of art Video and New Media at the Academy of Fine Arts at the University of Ljubljana. This was a beginning of a long and fruitful collaboration[2-4]. Their attention was shifted from merely presenting art works on the internet to actively help in producing new art in the area of new media and art installations. The multimedia concept developed for SVG was reused in several of Dragan's art projects. Several other technical solutions were developed for their projects that were challenging from a purely technical viewpoint. In this way, experiment and new methods in computer vision were done". The technical expertise of the Computer Vision Laboratory, especially in computer vision and robotics, was used in several of Dragan's art-Internet installations. By adding the possibility to get real-time video from any physical point, which can be connected to the internet, one can effectively blend actual and virtual spaces.

Hence, the next project was the development of a module for active live video observation over the Internet. Live video transmission over the internet and interactivity are becoming more and more popular. This very moment one can find thousands of cameras all across the world which are connected to the internet that can be used as remote eyes. Video offers information that static images can not. Therefore, intelligent control of video capture by means of changing the view direction of the camera, spatial structuring of visual information, as well as generation of visual summaries are essential for successful application of this technology.

To study user-interface issues of remotely operable cameras and provide a testbed for the application

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of computer vision techniques (motion detection, tracking, security) the internet video server (IVS) system[5,6] was developed. The system consists of a CCD camera mounted on a robot pan/tilt manipulator that makes possible to turn the camera in any direction. Using panoramic images assembled out of all possible camera views as a background for the live video image the user gets a much better understanding of the remote location and a proper context for selecting the new direction of the camera.

The multimedia concepts developed for SVG, along with the IVS active observation system, were used in a series of interactive installations by Srečo Dragan. ROTAS-TENET (May 1996) was dedicated to the architect Jože Plečnik by connecting to new technological means the Hradčany castle in Prague with the Prešeren square next to the Three Bridges in Ljubljana, both sites enhanced by Plečnik's architectural intervention[6]. NETROPOLIS-CYBORG'S EYE Project (1997) was prepared for the European month of culture in Ljubljana[7,8]. It offered telepresence experience on the internet at various locations in Ljubljana, combining live video images with navigable virtual architectural space. NETROPOLIS-CLAVIS URBIS (1998) was exhibited at U3, 2nd Triennale of Contemporary Slovene Art in Modern Gallery Ljubljana. In addition to previous technologies this project featured a camera carrying robot telecontroled over the internet[3,9].

Collaboration with Srečo Dragan extended to his students at the Academy of Fine Arts and the ArtNetLab initiative was started as a production environment for new media art installations. Students of fine art and computer and information science collaborate in production of new media installations since 1996[2,4,10].

Three interactive installations, '15 seconds of fame'[11], 'Virtual skiing'[12] and 'Dynamic anamorphosis'[13] which all use computer vision, has also been produced as these are the main research areas. A core task in this people-centered computer vision objective is face detection which with succeeding face recognition is an increasingly important goal in video surveillance which in turn is becoming a major focus of cultural production[14]. A video camera in combination with various types of displays has been used over and over in different art installations.

2. SLOVENIAN VIRTUAL GALLERY

The SVG was developed in the first half of 1995 with the aim to present Slovenian fine art on the internet[1]. In cooperation with distinguished Slovenian art-historians an overview of Slovenian art from the gothic period up to the present time was prepared. SVG consists of three main parts (Fig. 1(a)):

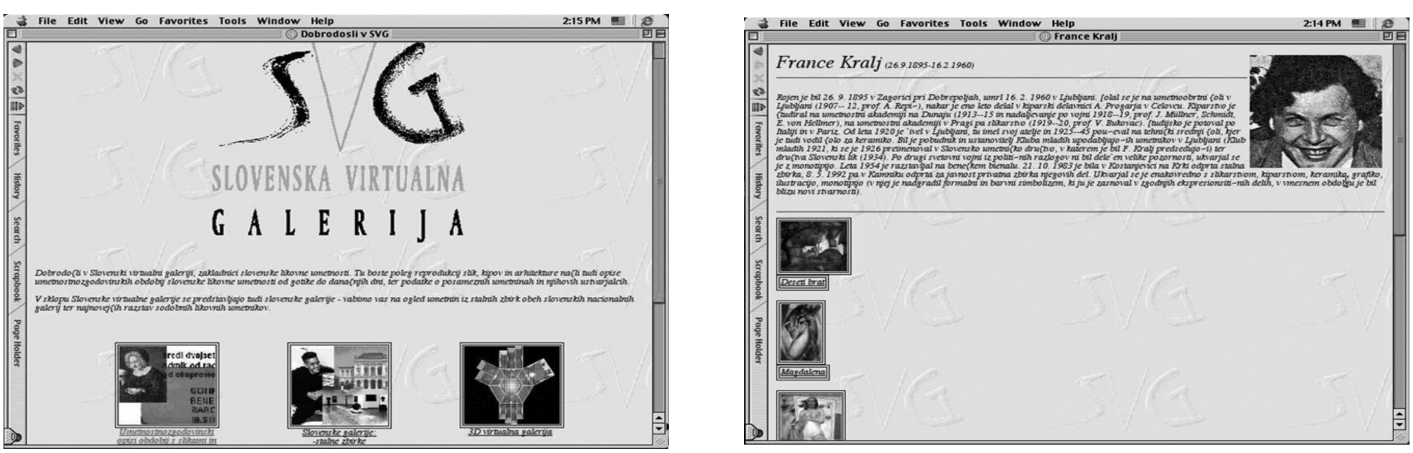
(a) Overviews of the main art historical periods that contain biographies of authors, each with an iconised index of their works (Fig. 1(b)).

(b) Permanent collections and current exhibitions in selected Slovenian art galleries.

(c) A 3D virtual gallery where the viewer can move through a virtual 3D architecture and view the paintings hung on the walls. By clicking on the paintings the user switches to the works and their authors in the first part of the SVG.

The SVG supports search of authors or works of art by using different keys (names, years, art techniques).

The virtual exhibition space of the SVG was implemented using a structure of inter-connected clickable-maps[1]. Each view of the 3D gallery space, which was initially constructed as a classical CAD model, was pre-rendered and converted to a clickable map by addition of carefully selected links to the next possible views. By clicking on the pre-selected areas of the clickable map the observer moves to the corresponding destination. Thus, a selected sequence of such clickable maps forms a walk through the virtual gallery. If a visitor of the virtual gallery clicks on any of the paintings which are hung on the walls he gets to the presentation of the paintings in the first part of the SVG. In this way all parts of SVG are interconnected. Although similar



(a) (b)

Figure 1. (a) Home page of the Slovenian Virtual Gallery and (b) Biography of the painter France Kralj

result could be obtained using a VRML model, The present implementation was much faster at the time and enabled much greater flexibility in connecting to different parts of SVG since each step in a walk was just a link to another HTML document. Such predetermined paths through a virtual space are also easier to handle for a novice user who can get quite easily lost, if a multitude of options are open such as in a VRML rendered virtual space.

SVG was warmly received in Slovenia[15] and, as judged by a high number of visits, on the internet in general. In 1996 the McKinley Group's online editorial team rated SVG as a '4-star' site excelling in 'Depth of content', 'Ease of exploration', and 'Net appeal'. Unfortunately, no institution in Slovenia at that time showed any interest to maintain and upgrade the SVG system that was a result of student work and was therefore no longer maintained. While the first part of SVG is fairly content stable, the second part was supposed to offer information on current exhibitions in several galleries.

In 1999, the Union of the Slovene Fine Artists Associations (ZDSLU) sponsored a project which was inspired by SVG. A VRML model of the Jakopič Pavilion, which was demolished in 1962, was built to serve as an environment for virtual exhibitions of Slovenian artists on the internet and to celebrate the anniversary of Rihard Jakopič[16]. Rihard Jakopič was the premier Slovenian impressionist painter who in 1908 actually financed the building of the pavilion in Ljubljana. The virtual pavilion, which closely follows the original plans of the architect Maks Fabiani, includes a 3D model of Jakopič's death mask which was rendered using a structured light range sensor (Fig. 2).

The SVG, judged by its implementation, was a typical first generation website. Due to the lack of appropriate tools at the time of development, all implemented in PERL[1]. Data was stored in files

Figure 2. Jakopi˘c's death mask

that were directly manipulated. Since there were just a few typical types of documents in the SVG, patterns to generate HTML documents were used. It was not necessary for the administrator of the system, whose role was to add new content to the SVG, know the html syntax. Additional features of the SVG system were a distributed database and remote management of the system.

In the span of just a few years, however, the web-related technology has experienced a tremendous growth. Many museums and galleries still use custom-built websites. The development and maintenance of such solutions can be expensive and the future lies in using one of many general tools for web content presentation and management. Various commercial and more importantly open source solutions that make websites of museum and art galleries much easier and faster to develop and maintain are available in the market. The resolution of images is steadily increasing and beside 2D imagery, 3D data and models of 3D artifacts can now be easily created and integrated in web presentations.

3. TOOLS FOR CREATION OF WEB PRESENTATIONS

Four of the more popular state of the art systems for creation of web presentation for art galleries and art museums are Drupal, Joomla, Typo 3, and Wordpress. Beside all the functionality needed for such complex websites these focus on aesthetics, web standards, and usability also. All four of them are free for use.

3.1 Drupal

Drupal[17,18] is a free and open source content management system (CMS) written in PHP and distributed under the GNU General Public License. It is used for many different types of websites, ranging from small personal blogs to large corporate and political sites, including whitehouse.gov. Basic features of Drupal common to most CMSs include the ability to register and maintain individual user accounts within a flexible and rich permission/privilege system, create and manage menus, RSS-feeds, customise page layout, perform logging, and administer the system. Drupal provides options to create a classic brochureware website, a single- or multi-user blog, an Internet forum, or a community website providing for user-generated content. Drupal was also designed to allow new features and custom behaviour to be added to extend Drupal's core capabilities. This is done via installation of plug-in modules created and contributed to the project by open source community members. Although Drupal offers a sophisticated programming interface for developers, no programming skills are required for basic website installation and administration. The Indianapolis Museum of Art website uses Drupal as its back-end system[19].

3.2 Joomla!

Joomla![20] is an open source content management system platform for publishing content on the world wide web and intranets. It is written in PHP, stores data in MySQL and includes features such as page caching, RSS feeds, printable versions of pages, news flashes, blogs, polls, search, and support for language internationalisation. The Joomla! package consists of many different parts, which allow modular extensions and integrations to be made easily. Examples are extensions called plugins that extend Joomla! with new functionality. In addition to plugins, more comprehensive extensions are available that allow webmasters to perform such tasks as build a community by expanding user features, backup a website, translate content, create URLs that are more friendly to search engines and add shopping cart functionality for e-commerce website. The Guggenheim Foundation[21] with its international chain of museums uses Joomla! for creation of its websites.

3.3 Typo3

Typo3[22] is a free open source CMS written in PHP for enterprise purposes on the web and in intranets. It offers full flexibility and extendability while featuring an accomplished set of ready-made interfaces, functions, and modules. It can run on Apache or IIS on top of Linux, Microsoft Windows, OS/2 or Mac OS X. Along with a set of ready-made interfaces, functions and modules Typo3 has a large repository of extensions, allowing flexibility and extendibility. More than 4000 extensions are available for download under the GNU General Public License. Typo3 has a web frontend, which presents a Typo3-based website to its users, along with a web-based backend, used by authors and site administrators to manage content for the website. The system is based on templates. People can choose an existing template and change features such as logo, colors, and fonts, or they can construct their own templates using a configuration language. National Museum Del Prado in Spain[23] uses Typo3 for the creation of its web presentation.

3.4 Wordpress

WordPress[24] is an open source blog publishing application powered by PHP and MySQL which can also be used for basic content management. It has many features including a user-friendly workflow, a rich plugin architecture, and an advanced template system. WordPress has a template system, which includes widgets that can be rearranged without editing PHP or HTML code, as well as themes that can be installed and switched between. The PHP and html code in themes can also be edited for more advanced customisations. WordPress also features integrated link management; a search engine-friendly, clean permalink structure; the ability to assign nested, multiple categories to articles; and support for tagging of posts and articles. WordPress has a rich plugin architecture that allows users and developers to extend its functionality beyond the features that come as part of the base install. Native applications exist also for smart mobile platforms (iPhone/iPod Touch, BlackBerry) that enable content access and also some administration. The Toledo Museum of Art[25] in Ohio selected Wordpress for creation of its web presence.

4 LIVE VIDEO OVER THE INTERNET

In 1996, system for active remote video observation over the internet which was named Internet Video Server (IVS)[5] was developed by author. The IVS system consists of a camera mounted on a robot pan/tilt manipulator that makes possible to turn the camera in any direction. The user of the IVS system observes the video image and controls the direction of the camera in a browser window (Fig. 3).

Figure 3. IVS user interface. Buttons for moving the camera were provided.

This initial IVS interface required the user to press the left/right and up/down buttons to move the camera. In 1996, due to buffering, slow, and uneven reaction times of the network,these controls did not seem to be very predictable from the user's point of view. A user would, for example, press the button for moving the camera one step to the left. If nothing happened in a few seconds, he would press again the same button or try a different operation. Due to buffering, he would suddenly get a new image that could be a result of just the first command, or a combination of any number of subsequent commands.

The reaction time of the system depended mostly on how the camera and the pan/tilt unit was connected to the Internet. Many types of connections were tested, ranging from direct computer network connections to GSM mobile phone networks. Between August 1996 and May 1998 the IVS system was accessed and used more than 40000 times from more than 1000 different computers all over the world.

Another problem with the user interface is more perceptual. If the viewing angle is small, one can easily loose the notion to which part of the scene the camera is pointing at. Observing a distant location with the help of the IVS or a similar system gives a very limited perception of that location which is not very different from looking at our surroundings through a long tube. These interface problems motivated us to design a better user interface for remote video observation[5]. Due to the precisely controlled position of the camera by means of the pan/tilt unit, individual images acquired by IVS can be assembled into a panoramic 360^{o} view of the surroundings (Fig. 4). This panoramic image is then used as a backdrop for the live video image, to give the user the correct context for his observation. The rectangle in the panoramic image indicates the attention window that in turn indicates the current direction of the camera. By moving the rectangle the user controls the direction of the camera. On the bottom of the web page the live video image in actual resolution (left) and a zoomed panoramic view (right) are shown.

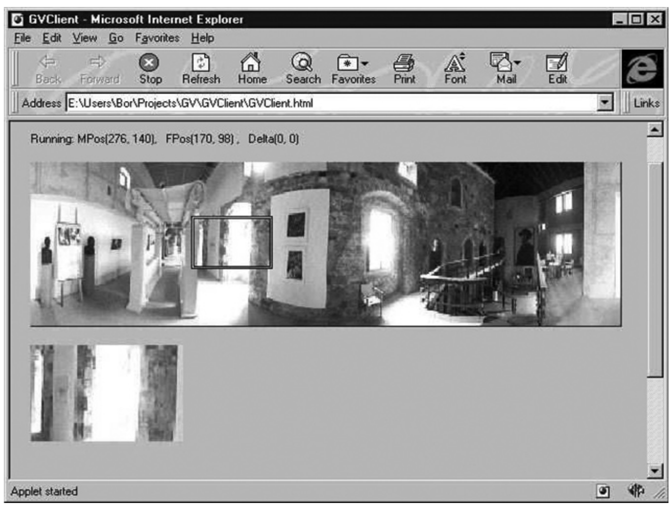


Figure 4. The newer 'GlobalView' interface for IVS.

The commands for 'left' and 'right' move the camera for 15^{o} in horizontal direction and the commands for 'up' and 'down' move the camera for 5^{o} in vertical direction (Fig. 3). To move the camera for 180^{o} in horizontal direction the command for 'left' or 'right' has to be applied 12 times and to move the camera for 45^{o} in vertical direction the command for 'up' or 'down' has to be applied 9 times. These figures tell us that if one wants to find some object on the scene, needs to preview the whole scene at least 100 camera movements are required. Using an updatable panoramic view as a part of the user interface the number of camera movements required to find some target can be decreased significantly: to one move only. In the new 'GlobalView' interface (Fig. 4) one can simply drag the live video frame over the static panoramic image to define the new camera position.

At system startup, the panoramic image is generated first by scanning the complete surroundings of the camera. When a user starts interacting with the system he is shown the whole panoramic image. A rectangular frame in the panoramic image indicates the current direction of the camera. Inside this attention window the live video image is seamlessly superimposed onto the panoramic image. By means of a mouse the user can move the attention window and in this way select the direction of the camera. When the attention window is at the desired location of the user prompts this to the system. From the position of the attention window within the panoramic image of the physical coordinates of the next camera direction are computed and the appropriate command is issued to the pan-tilt unit. When the camera is moved to a new direction, the last image from the old position is pasted to the static panoramic image. In this way the panoramic image is constantly updated in the areas of most interest to observers.

4.1 Generation of Panoramic Images

Panoramic images have been traditionally generated by special photographic cameras and photographic techniques by means of rotating the whole camera or just the aperture in the camera lens. Using a digital camera two general approaches are possible, to use conventional image-based systems and assemble several images or use special omnidirectional sensors. Omnidirectional sensor setups use specialised cameras or camera systems that are able to acquire omnidirectional visual information. Optics of such sensors use a fish-eye lens or combine standard lenses on a video camera with a conic, spherical, or paraboloidal mirrors.

These images, which cover a complete half sphere, must be mathematically processed to free them of severe distortions and get a proper perspective view. The advantage of this approach is that the whole panorama is imaged at once and that several users can move their own 'virtual camera' over this image to observe the part of the scene they are interested in. However, the benefit of such single step image capture is reduced by a very uneven resolution of these panoramic images. The majority of the image covers the sky or the ceiling of indoor spaces while the usually more interesting parts of the image are on the boundaries where the resolution is the poorest. To get useful information from both hemispheres, two such parabolic mirrors and cameras must be applied at once.

Assembling several images involves camera rotation and/or integration of overlapping images taken with a regular camera. The panoramic images obtained in this way have a more uniform resolution. By panning the camera over a scene and composing the video frames, large panoramic images of arbitrary shape and detail can be created[26]. To automatically construct those panoramic images, however, one must derive the alignment transformations-based directly on images or some other parameters that are gained automatically.

If the camera direction and the horizontal and vertical view angles of the camera lens are available then they can be used as alignment parameters. This makes possible for the fast automatic panoramic image composition. Using the pan-tilt unit one can know the precise camera direction within the whole panoramic image.

One can generate static 360° panoramic views by turning the camera (in horizontal and, if necessary, also in vertical direction) and assembling the pictures into a single slit. To get a rectangular panoramic image the individual images must be transformed from sphere to cylinder coordinates. If one is scanning only the area in the level of the camera horizon with a small vertical angle this transformation is not necessary since the image distortion is small. In this case, the vertical angle of panoramic images is about 90° and therefore the transformation is necessary to assure smooth panoramic images.

To achieve smooth lines and at the same time avoid the need of any geometric transformation of images, a brute-force scanning approach can be used. In the brute-scanning approach only a few center columns are taken from each image since the distortion increases from the center vertical line outward and only the center column has no distortion at all. Therefore, the brute-force scanning approach increases the number of images significantly. The number of center columns taken from each image is a compromise between quality and time that is needed for scanning the whole panoramic image.

In general, several cameras could be controlled, each by a separate attention window, all superimposed on the same panoramic image. Different focal length of the lens would result in attention windows of different sizes. Even zoom lenses could be controlled interactively by resising their attention window. In such an interface images form an omnidirectional system offering peripheral, low resolution image could be combined with a high resolution focal image.

4.2 Application of IVS

The new 'Global-view' IVS interface was used for the first time in June 1997 during the exhibition of the painter Silvester Plotajs Sicoe in the Gallery of Union of the Slovene Fine Artists Associations in Ljubljana. On the static panoramic images, taken in each room of the gallery (Fig. 5), one could click on paintings to get the corresponding pre-scanned images of these paintings and other information about the painter (Fig. 6).

From the current position of the IVS platform, however, a web user could receive live video as well as control the camera to observe not only the sterile static exhibition, but also the visitors moving through the gallery. In case of SVG, one has to render a virtual gallery space, In the present study panoramic images of the actual gallery spaces as the backdrop for selecting and viewing of individual paintings. The IVS system was used also in the context of several art installations by Srečo Dragan.

5. NEW MEDIA INSTALLATIONS OF SREČO DRAGAN

While the efforts of Computer Vision Laboratory in promoting Slovenian fine art over the internet did not receive any institutional support, a very stimulating and fruitful collaboration started with the new-media artist Srečo Dragan. Under his influence

Figure 5. 360° panoramic image taken in ZDSLU gallery during exhibition of Silvester Plotajs Sicoe in 1997.

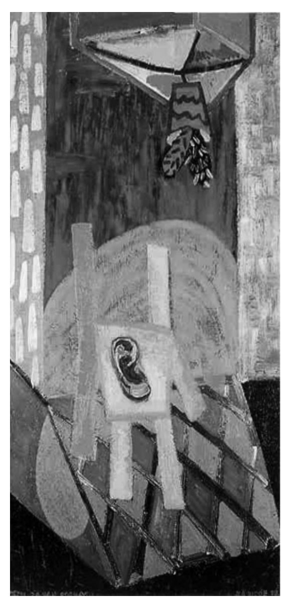


Figure 6. 'Chair for van Gogh', Silvester Plotajs Sicoe (oil on jute, 100×180 cm)

the Computer Vision Laboratory shifted its art-related activities to new media. A short description of several of Dragan's new media installations were given, then the ArtNetLab insitiative is discussed that enabled the production of more than hundred student new media projects in the past 10 years. At the end of the section five new media projects are described where computer vision methods play a central role (Fig. 7).

Figure 7. Exhibition of Srečo Dragan's electronic art projects in gallery Equrna, Ljubljana in 1997.

Srečo Dragan is one of the pioneers of video art and conceptual art in Slovenia and now a professor at the Academy of Fine Arts at the University of Ljubljana. Dragan was eager to explore and use any new technological solutions that related to his artistic interests. The multimedia experience-based on SVG, in combination with our module IVS for active internet video observation, was used in several of Dragan's art-internet projects and installations[27-30]. The Computer Vision Laboratory was instrumental in most of his recent work.

These projects offered, in general, the visitor a blend of actual and virtual spaces that could be visited over the internet. Visitors on the web could control the view direction of the camera to interactively observe actual physical locations that were again in an inventive hypertextural fashion connected to other virtual spaces or other visual or textural information.

5.1 ROTAS–TENET

The first joint interactive internet installation ROTAS–TENET was entirely dedicated to the architect Jože Plečnik (1872–1957) and his exhibition 'Architecture for the New Democracy' at the Hradčany castle in Prague (Fig. 8). Plečnik who was also a professor of architecture at University of Ljubljana actually renovated the Hradčany castle in 1920's. During the opening ceremony on Hradčany the IVS camera was set up on the Prešeren square next to the Three Bridges (Fig. 9), a demonstration of Plečnik's mastery in urban development, to spiritually link Ljubljana and Prague by new technological means. In the

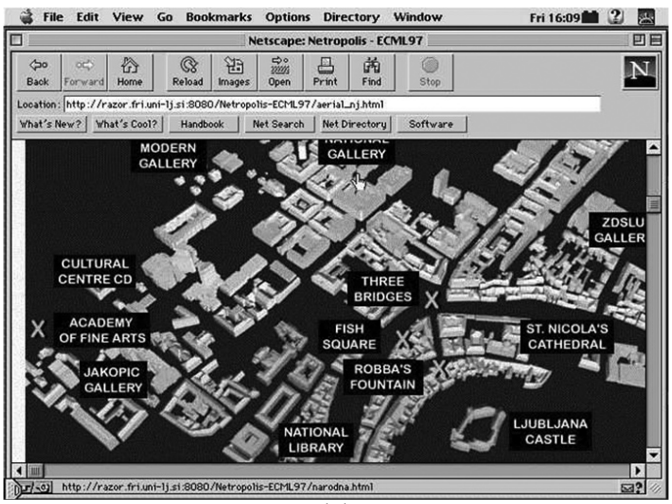
Figure 8. Web project ROTAS–TENET, 1996.

Figure 9. 360° view of the Prešeren Square at the hearth of Ljubljana.

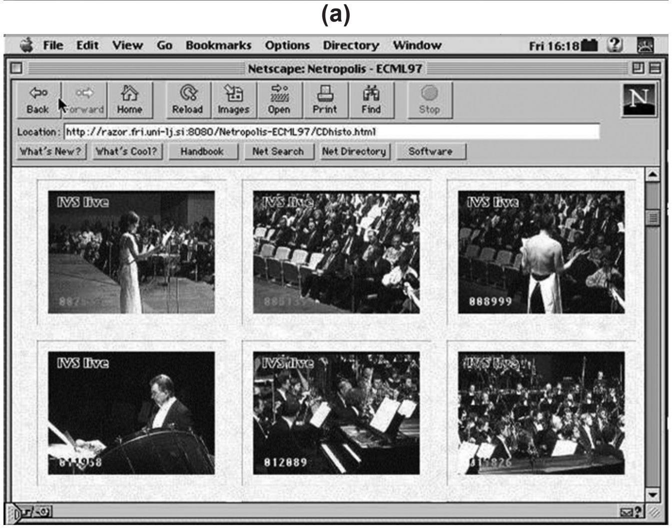
website was included also a computer model of Plečnik's plan for a new Slovenian Parliament which was never realised. This event in May 1996 marked also the first occasion when life video from a public space in Slovenia was available on the internet[6]. The two most complex joint art-internet projects were Netropolis–Cyborg's Eye and Netropolis–Clavis Urbis.

5.2 Netropolis–Cyborg's Eye

The Netropolis–Cyborg's Eye project was prepared for the European month of culture in Ljubljana (ECML) in the period of 15 May/5 July 1997[8,31]. The project was dedicated to artistic research and experiment and was supposed to serve as a reference point that enables art to enter the third millennium. The project was realised as an interactive installation of telepresence on the internet that has at various locations and at different times connected Ljubljana with the world. The project was a combination of a navigable virtual architectural space, representing Ljubljana on the internet—NETROPOLIS (Fig. 10 (a))—and of live video images, sent by means of a camera that could be controlled over the Internet from the selected points in the city—CYBORG'S EYE (Fig. 10 (b)). At these points one can cross from the (live or recorded) video images over into the digital city model and back again. At selected locations in the city 360º opanoramic pictures were recorded which could be viewed interactively (Fig. 10). The conceptual plan of an interactive access from one space to another is only possible as a view from the utopian site, a non-existent, excluded point of view, which is the center of all actual and virtual plans of space and time. Additionally, images of other ECML events were digitised from video clips prepared by TV Slovenia and presented in the chronicle section of the project web page. Unlimited possibilities of interactive dialogue formed a temporal image of the whole event that is still available on the internet[10].



(a)



(b)

Figure 10. Netropolis–Cyborg's Eye project, 1997. (a) 3D model of the center of Ljubljana with locations indicating where panoramic images can be interactively viewed and (b) Video frames transmitted through IVS from the opening ceremony.

5.3 Netropolis–Clavis Urbis

Netropolis–Clavis Urbis was the title of Srečo Dragan's participation at the U3, 2nd Triennale of Contemporary Slovene Art in Modern Gallery Ljubljana, 14 November/11 January 1998. The participants of U3 were selected by the curator Peter Weibel.

Netropolis-Clavis Urbis is based on a camera carrying robot telecontrolled via the internet (Fig. 11). The robot[9] can be directed via the internet to several locations in Ljubljana, represented in the gallery space by anamorfic images; at the same time, it sends a picture of the actual gallery space to the spectator-actor. But when the camera settles on the picture of the selected direction, the image on the screen transforms into a virtual, computerised picture of the city. The project thus connects the real gallery space with both the real and virtual spaces

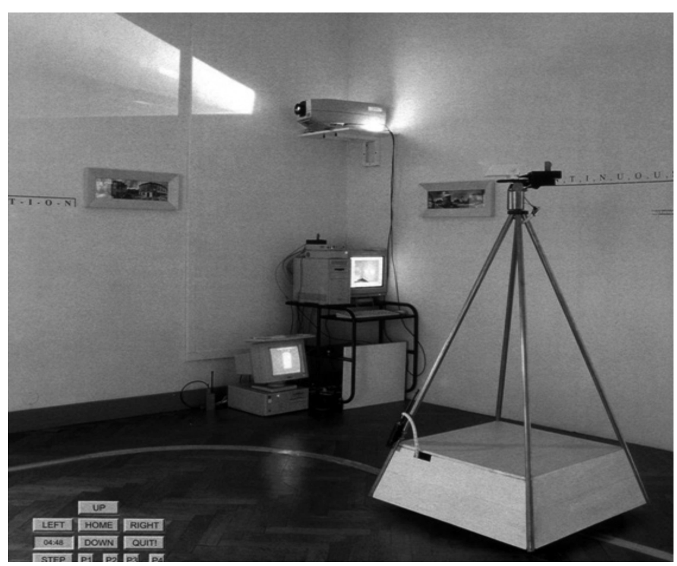


Figure 11. Srečo Dragan's exhibition at U3, Modern Gallery, Ljubljana in 1998.

of the city of Ljubljana and with the dislocated word of computer networks[32].

6. ARTNETLAB NEW MEDIA PRODUCTION

In the fall of 1999, Professor Srečo Dragan and author started a permanent collaboration that we entitled ArtNetLab. ArtNetLab teams up fine-art students with computer science students to produce art projects involving internet, new media, interaction and other new information technologies[2,4]. This collaboration resulted in a new interdisciplinary study program ‘Computer Science and New Media’ at University of Ljubljana.

For the fineart students the main benefit of this collaboration is to get hands-on experience with the latest new IT and the technical support of computer science students to build technically sophisticated websites and art installations that they themselves envisioned. On the other hand, for the computer science students, it is important to get experience in negotiating, designing, building and managing small but self-contained projects for customers who are in this case fine-art students. The experience of working in teams is for both kinds of students very important since it is the norm in real life but rarely practiced during the university education.

The most successful projects were exhibited at the Annual International Festival of Computer Arts in Maribor and later in Ljubljana. A selection of best projects was exhibited also internationally and some graduates who participated in this initiative are now internationally known artists. A comprehensive archive of all projects is available on the ArtNetLab website[10].

From the 2001 ArtNetLab production the project ‘Wap Kitchen’ by Dušan Bučar must be singled out because of its technical excellence that enabled participants to interact with kitchen appliances using mobile phones and the WAP protocol[33]. An integral part of the ‘Wap kitchen’ installation was also a mobile robot that was freely moving among the visitors by avoiding them since the built-in sonar sensors could detect obstacles in real-time.

Computer vision is now widely used to sense the presence and actions of humans in the environment. Novel surveillance systems can reliably track and classify human activity, detect unusual events and learn and retrieve a number of biometric features[34]. Due to the low cost and the ubiquity of personal video technology, the research has recently shifted towards developing novel user interfaces that use vision as the primary input. In the area of personal computing, the most prominent areas of research are desktop interfaces that track gestures[35]. On a wider scale, human motion can be used to interact with smart environments[36].

In the next section, short descriptions of five projects produced in the framework of ArtNetLab are given, all of them using video as means of interaction.

6.1 15 Seconds of Fame

The installation ‘15 seconds of fame’ was inspired by Andy Warhol’s celebrated statement that “In the future everybody will be famous for 15 minutes” and his photography derived paintings of famous people. Warhol took faces from arts and politics from mass media, banal in their newspaper everydayness, and transformed them into portraits. The installation tries to make instant celebrities by reversing Warhol’s process—making Warhol-like celebrity portraits of common people and putting them on the gallery walls to make the portraitees implicitly famous[11,37]. The faces for the portraits made by the installation are selected by chance out of all people in front of the installation to allude that fame tends to be not only short-lived but also random (Fig. 12).

Figure 12. A group of people in front of the installation ‘15 seconds of fame’, Maribor, 2002.

The visible part of the ‘15 seconds of fame’ installation consists of a computer monitor framed like a painting. A digital camera is built into the frame so that only a round opening for the lens is visible. Pictures of gallery visitors which are standing in front of the installation are taken every seconds by the digital camera mounted in the frame above the monitor. The camera is connected to a computer which detects all faces in each picture, randomly selects a single face, makes a pop-art portrait out of it and displays it for 15 seconds on the monitor.

The ‘pop-art’ filter drastically reduces the number of different colours by joining similar looking pixels into uniform regions by combining posterise, color balance and hue-saturation functions with an additional process of random coloring. In this way, millions of different effects were achieved (Fig. 13 (a-h)).

6.2 Smart Wall

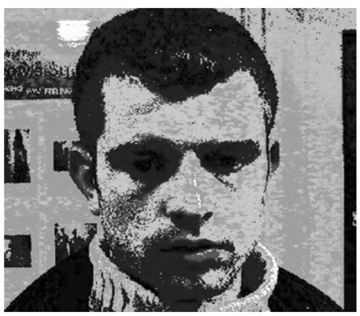
The main goal of the Smart Wall project[2] is to provide a platform for a rapid prototyping of computer supported interactive presentations that sense human motion. The system is composed by a front-end application, where the developer defines


(a)


(b)


(c)


(d)


(e)


(f)


(g)


(h)

Figure 13. Pop-art portraits generated by the installation '15 seconds of fame'.

a number of hot spots in a camera view, a Hotspot Processor, which senses the activity in each of the hot spots, and a Player, which displays interactive content triggered by the activity in hot spots. By associating actions or sequences of actions in the environment to actions in the interactive presentation, a variety of complex interactive scenarios can be developed and programmed with ease. Due to the modular architecture, the platform supports distributed interaction, connecting physical activity and content display at remote locations (Fig. 14).


Figure 14. Smart Wall in action, 2005.

The major motivation of Smart Wall framework is to provide an open environment to develop and experiment with interactive presentations in public space. The interactive area can be any public area that is observed by a camera connected to a computer. The field of view of the camera can then be divided in a grid of cells that define the smallest areas where activity will be detected. The resolution and consequently, the size and the number of the cells, are defined by the developer. Multiple neighboring cells on the grid can then be joined in a single ‘hot spot’, representing thus an interactive entity that promotes its state to other modules.

Each hot spot can define an action that occurs when the activity in the hot spot area exceeds a certain threshold (i.e., a person enters the area). The presentation on the screen is controlled by such actions or by a sequence of actions.

6.3 Virtual Skiing

Real-time interaction of people with virtual environments is a well-established concept but finding the right interface to do it is still a challenging task. Wearing different kinds of sensors attached to the body of the participants is often cumbersome. Computer vision offers the exiting possibility to get rid of such sensors and to record the body movements of participants using a camera. People, their appearance (i.e., face), their emotions and the movements of their bodies are becoming an important object of study in computer vision research[34].

The number of application areas for virtual environments is growing since the cost of technology for making virtual environments is in general going down. Sporting games in general are an attractive area for using virtual technology. Many training machines for cycling, running, rowing are enhanced with a virtual world to make the training more interesting. Instead of looking at a static scene in a fitness room one can get the feeling of moving along a real scene or even to race against other real or virtual competitors. At their most complex, virtual exercisers are sophisticated simulations that deliver the demands, stresses, and sensations of a sport or exercise with unprecedented verisimilitude and precision.

Artists experiment freely with new technology and try to invent better and new ways of interfacing with virtual world[14]. The project of virtual skiing was initiated as an interactive art installation which gave more freedom to experiment and to show results to a wider public in an art gallery setting[13,37].

The installation for virtual skiing consists of a room with white walls and a floor covered with artificial snow. The skier stands on a pair of skis that are attached to the floor. The virtual slope is projected on the entire wall in front of the skier (Fig. 15). By using the same movements as on real snow the skier can negotiate also the virtual slope. The movements of the skier are captured by a video camera in front of the skier which in turn controls the animation of the virtual slope. The

Figure 15. Skier performs the same movements as on real skis to turn on the virtual ski slope.

skier can navigate down the virtual slope just by changing the posture of his body. By the degree of his body shift right/left he controls the radius of the right/left turn. By lowering his body center he increases his speed. In the process of navigating down the slope the skier must avoid the sparsely arranged trees. The video camera can be seen at the bottom of the projection.

The interface is very intuitive since the skier just repeats the actions that he knows from real skiing and learns to control his movement in the virtual world in less than a minute. The system does not need any robotic or mechanical devices. The image processing is also not demanding since no real forces are involved and therefore no sophisticated motion analysis is required for biomechanical interpretation of the skier’s motion.

6.4 Virtual Dance

The Virtual Dance project[38] presents a system that is able to track dance movements and integrates the motion in an interactive video. The idea is to provide a flexible framework which allows the artist to set up an interactive virtual dance performance by defining markers, videos and interactive visual icons associated with markers. The system is then able to interact between the real movement and the virtual movement. We used standard tracking methods and modified them to support fast moving markers, small markers and discontinuous tracking of markers.

Consequently, by dancing, the dancer creates two patterns of movement in two different spaces. The first pattern is produced in the 3D real world. The second pattern is reflected in the two-dimensional virtual space. These two representations are inseparable. The virtual dance is shown on the screen and in this way the real world dance extends to a new complementary dimension of expression (Fig. 16).

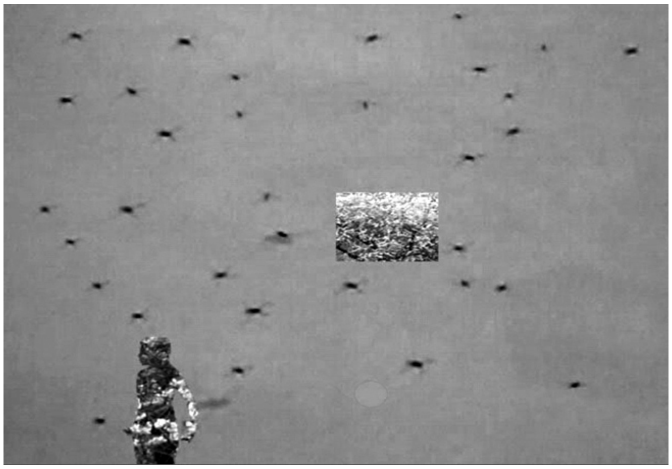


Figure 16. Virtual dance, 2008.

The real dance is recorded by a camera in real-time. While the dance is limited by space, no spatial constraints should be imposed by the camera and other technology that processes the video. Therefore, the system must handle tracking of markers that leave the camera field of view and reappear, or markers that are temporarily occluded by the dancer, by objects in the scene, or by other dancers. In this way, the dancer can also leave the scene and reappear multiple times during the performance, and the system must be able to robustly track the markers thorough the performance.

The virtual dance is produced as a consequence of real dance. The user defines the virtual space while the dancers dance, so the dancer manipulates the virtual dance and its presentation. The application produces a movement of the virtual representations that is in correlation with markers on the dancer's body. The user interactively chooses the representation of a marker in the virtual video dance. The representation can be a picture or an animated two-dimensional sequence, e.g., a movie clip of the dancer representing a pre-recorded movement. The user can also choose the background of the virtual dance and can change the size and the color of virtual markers.

The real dance and its virtual presentation are inseparably connected because of real time video processing. Every movement in real world immediately produces a movement in virtual world. Dancers can observe the virtual dance that is produced by their movement. Hence the dancers can also interact with the virtual space through their dance. A dancer can observe the virtual dance and produce a brand new story and movement in the virtual world. If the dancer chooses some particular presentation of her markers in the virtual dance and if she moves in some special way, she can produce a new story in the virtual world which is not focused on tracking the real world movement, but it becomes a virtual story that has no connection with dance but is still directed by the dancer.

6.5 Dynamic Anamorphosis

The concept of dynamic anamorphosis[13] can be defined as a classical or static anamorphic image requires a specific, usually a highly oblique view direction, from which the observer can see the anamorphosis in its correct form. Dynamic anamorphosis adapts itself to the changing position of the observer so that wherever the observer moves, he sees the same undeformed image.

The dynamic changing of the anamorphic deformation, in concert with the movement of the observer, requires from the system to track the 3D position of the observer's head and the recomputation of the anamorphic deformation in real time. This is achieved using computer vision methods which consist of face detection/tracking of the selected observer and stereo reconstruction of its 3D position while the anamorphic deformation is modeled as a planar homography. Dynamic anamorphosis can be used in the context of an art installation, in video conferencing to fix the problem of the missing eye contact and can enable an undistorted view in restricted situations. Anamorphosis serves as a model for the concept of the gaze, which suggests that visual appreciation rather than passive 'looking' requires active 'observing'. The Big Brother from the film Nineteen Eighty-Four (1956) after George Orwell's novel of the same name published in 1949. The Big Brother personifies complete surveillance by the authorities of all members of the society, mainly using telescreens with the image of the Big Brother. To resolve the anamorphis deformation move his head to the right and up so that the upper-right corner of the image is the closest to the eyes.

Dynamic anamorphosis disassociates the geometric space in which the user moves from the visual cues he sees, since wherever the observer moves, he sees the same image. The installation promotes a human face (Fig. 17) with the eye gaze directed straight ahead to meet the eyes of the installation observer. It requires a dark room with the video projection over an entire wall so that the only visible cues seen by the user are given by the projection. The light reflected back into the room from the projected image must sufficiently illuminate

Figure 17. The Big Brother from the film Nineteen Eighty-Four (1956).

the scene that face detection can be performed. Since the installation can truly be experienced only by a single user, the entrance to the room with the installation should be controlled.

7. ADAPTIVE DIGITAL SIGNAGE

Due to larger size, better quality and lower cost digital flat-panel displays are slowly replacing static displays in commercial and public use. Digital signage has several advantages over static displays. Since digital displays are usually connected to a central server, the displayed contents can be changed on the fly, and much more information can be displayed in sequence than it can be fitted onto a static display. Also, video and other dynamic visual effects can be displayed beside static contents[39,40].

Normally, there is just a one-way flow of information in these systems. From the central server content flows to the distributed displays according to some pre-determined scenario. The system is blind to what is actually happening in front of the displays. The connection between the display clients and the central server can be used to send some feedback from the displays.

The easiest way of feedback offers a video camera mounted on the display which shows what is going on in front of the display. Using computer vision methods one can automatically determine not only the number of people in front of the display but estimate also their gender and age. Such an automatic audience measurement system can offer much more reliable statistics on how many people have seen a particular message than the usual estimates used in advertising. The feedback information on the number and kind of people in the audience in front of a particular display can be used not only for gathering statistics but to actually adapt in real-time the scenario for displaying the available multimedia material. Especially in advertising, most commercial messages are targeted to specific groups such as male/female, youngsters/seniors, etc. Using digital characterisation to classify people in such broad categories can substantially increase the effectiveness of advertising.

A further step in this direction would be to engage the observers of digital displays in some interaction. The usual technology for interaction in public spaces such as touch screens or other input devices are in the context of digital signage not suitable since screens for digital signage are larger and often not accessible. One can envision a visual interface where people could interact with the displayed contents using gestures or the position of their whole body to make selections.

Such audience adaptive digital signage systems are on the brink of commercial deployment. The most critical part of such an audience adaptive digital signage system is related to computer vision, to detect and track faces in the audience and to classify the faces into some broad gender and age-based categories. Other parts of the systems are also important, for example how to automatically generate scenarios according to the material that needs to be displayed and the behavior of the audience. Production of appropriate multimedia material is also important for the success of such systems since materials produced for other type of media (TV, internet, etc.) can not be directly reused.

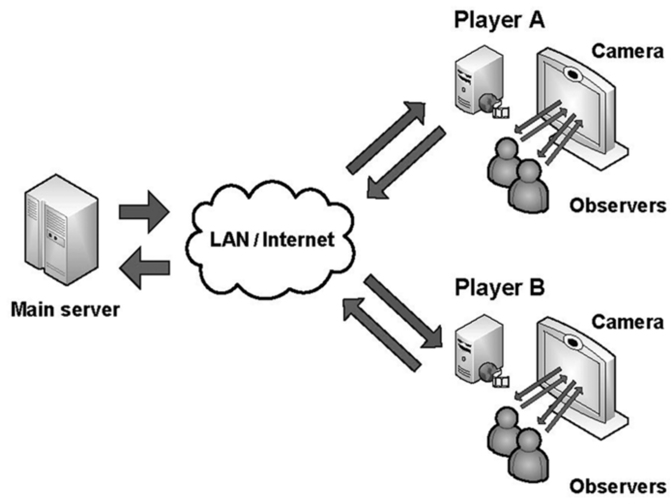


Figure 18. Adaptive digital signage system setup and information-flow.

A prototype of an audience adaptive digital signage system to study in particular the computer vision part of the system has been built[41]. Changing and sometimes adverse illumination of the scene in front of the display as well as constant movement of people in the audience can make the detection and characterisation of faces quite a challenge (Fig. 18).

8. CONCLUSIONS

Several art-related websites and art installations, ranging from classical presentations of picture galleries to interactive art installations using computer vision have been built in cooperation with the new media artists.

If a gallery or art museum website serves only the general public, short information about collections, some pictures, opening hours, and directions for finding the museum generally suffice. If, on the other hand, a museum website wants to serve also the art specialists, almost complete collections should be available scanned in high resolution, together with all other relevant information. This is of course a major, several years long undertaking, which must be carefully planed and is best organised in the framework of digitising the collection in high resolution. The accompanying web design must be more conservative with the primary goal of finding the relevant information fast. Several, mostly open source tools, are available for development of such multimedia web content.

Websites devoted to exhibitions of single authors or even art-internet installations are much less restrictive in design as well as in technological solutions since they are much smaller in content and usually short lived. The personal computer with its standard graphic interface is not the only vehicle for accessing digitised cultural contents. Mobile handheld devices are gaining in importance which usually require some restructuring of information due to their small display size on the one hand and large displays—digital signage on the other where the possibilities of interaction are still evolving. Mobile devices are important as guide and navigation tools, digital signage devices can also add an additional channel for providing information in museum and art galleries.

Contemporary arts interact with science and technology in many ways. The ArtNetLab initiative is a small but for Slovenia an important forum and meeting space where young inspiring artists, scientists and engineers can collaborate to bridge the traditional divisions of disciplines. The scale of recent development of media and technology has affected not only the workplace and the entertainment industry but also large areas of art (media art, video, computer graphics, animation, net-art, interactive art, virtual art, telepresence art, genetic art, etc.). It is, therefore, imperative for fine-art students to get some first-hand experience with the technology that enables the production of these new genres of art.

Mastering technology and off the shelf production tools by artists themselves is often not enough for advanced projects. New devices or interfaces must be designed, new software written and enabling them is one of the main benefits of the interdisciplinary and collaborative team approach. From an engineering or scientific point of view such projects are also very stimulating since they foster novel and alternative kinds of using new technology without the pressing demands for immediate profit. New media art projects offer a stimulating environment to experiment freely so that a new generation of artist-researchers and researcher-artist can emerge which will hopefully develop meaningful art for our times and set new agendas in science and technology that address today's real human needs.

From the human resources point of view, new educational programs are sorely needed to combine the knowledge of technology with design skills. In 2010 the ArtNetLab initiative resulted in a new interdisciplinary study programme 'Computer Science and New Media' at University of Ljubljana.

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