Bateau Ivre: An Artistic Markerless Outdoor Mobile Augmented Reality Installation on a Riverboat

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ABSTRACT

Bateau Ivre is a project presented on the Seine River to make a large audience aware of the possible developments of Augmented Reality through an artistic installation in a mobile outdoor environment. The installation could be viewed from a ship by a large audience without specific equipment, through nightly video-projection on the River banks. The augmentation of the physical world was implemented through real-time image processing for live special effects such as contouring, particles, or non-realistic rendering. The artistic purpose of the project was to immerse the audience into a non-realistic view of the River banks that would differ from the traditional tourist tours that highlight the main landmarks of Paris classical architecture.

The implemented software applied standard algorithms for special effects to a live video stream and reprojected these effects on the captured scenes to combine the physical world with its modified image. An analysis of the project output reveals that the impact of the effects in mobile SAR varies a lot, and does not correspond to the visual impact on a standard desktop screen.

Categories and Subject Descriptors

H.5.1 [Information Systems]: Information Interfaces and Presentation—Multimedia Information Systems; Artificial, Augmented, and Virtual Realities

General Terms

Algorithms, Design, Experimentation, Human Factors

Keywords

Mobile Augmented Reality, Augmented Reality, Real-time Image Processing, Heritage, Outdoor Digital Art

1. INTRODUCTION

Bateau Ivre has been designed as an entertaining art installation that would immerse an audience into a magical and unforeseen view of the Seine River banks while travelling on a tourist boat at night. The first purpose was to make a connection between current advances in Augmented Reality and citizens so that they would have a positive appreciation of scientific developments. The second issue was to use an extraordinary experimental playground to test various possibilities of digital enhancements of the physical world, and thus get a better knowledge of the efficiency of these effects at a large scale in various lighting conditions. The Bateau Ivre project was a successful event, allowing 4 groups of 150 people to travel along the River and discover various visual effects applied on the River bank architecture and vegetation during the night of June 5, 2010.

1.1 Artistic Purpose of the Work

The artistic part of the work was made by Bertrand Planes [10], a visual artist who has designed several Spatial Augmented Reality (SAR) [5] installations named Bump It! in various conditions: from simple volumes such as a cube [17] to more complex set-ups such as a small scale car model [18], or an historical organ [11].

By extending his work to a mobile installation on the Seine River, Bertrand Planes’ purpose through the Bateau Ivre installation was to offer a renewed approach to historical fluvial architecture and mass tourism in Paris. Classical night river boat tours in historical (central) area of Paris make use of powerful spotlights to light up the monuments that overlook the River. Bateau Ivre intends to replace these standard views of the classical heritage by a trip into a contemporary city area. It would offer hybrid views on the riverside architecture made of the real-time combination of digital special effects, green parks, and industrial buildings (see Figure 1 for the trip details and Figure 2 for a sample rendering).

The artwork was designed as a performance that combines a magical boat trip and a technical achievement. The view of the river banks offered by the Mobile Augmented Reality system is more than just a visual enhancement of a classical view of the Seine riverside. The work is intended to offer a digital view of the city to the onlookers. Through Bateau Ivre, the passengers of the boat trip are equipped with a digital vision, the vision of the machine. The project tells us about the future of our way to look at the world. The filters used to produce the special effects projected on the Seine river banks are standard filters used in image processing such as contouring, blurring, posterizing... These effects already belong to our collective imaginary. Through their projection on the physical world, they transport us into a new hybrid world in which the digital and physical lives are intertwined,
in which we access a new dimension of our environment. The trip is both a physical and a mental trip that questions our perception of our everyday life, strikes down prejudice, and promotes a renewed approach to an harmonious combination of a digitally enriched world.

In addition to reinvesting the scientific domain of Mobile Augmented Reality into an artwork and thus underline its artistic potential, the installation also intended to offer citizens an attractive approach to scientific research and education. By bringing science closer to citizens, government funded projects such as Futur en Seine, also hope to better attract young talents towards science.

1.2 Outdoor Mobile Augmented Reality and Spatial Augmented Reality

Mixed or Augmented Reality is the real-time combination of the virtual and physical worlds into a new environment where digital information is anchored to (registered with) real-world elements in a coherent manner. The registration issue is one of the big challenges in this domain, specifically when working in outdoor where it is not realistic to equip every building with visual markers. This issue is of course much more accurate when dealing with Outdoor Mobile Augmented Reality, the scientific domain of the Bateau Ivre installation that traveled along approximately 3 kilometers of the River banks.

Most Mobile Augmented Reality applications make use of backpack systems with head-worn displays [9] or hand-held devices [14] to compose views of the real-world with digital information. Recent hardware contains tracking devices, such as GPS and gyroscope, that can be used to define the position in the physical world. The technological constraints for the development of such applications are however quite high, and do not necessarily correspond to the budgets and needs of art installations. They are better suited for commercial, industrial, or cultural uses such as real estate merchandising, customer orientation and geo-tagged advertising, assistance for repairing or assembly, building construction supervision, museum touring, archeology and historical site augmentation... The use of specific equipments for the visualization of Augmented Reality applications such as goggles, head-mounted displays, or handheld devices do not make these applications well-suited for artistic installations targeting a large audience. In addition, the equipment of users with intrusive devices can prevent them from engaging into the installations and diminish their appreciation of the works. The use of video-projection for augmentation also allows a better shared experience between members of the audience.

Spatial Augmented Reality (SAR) is a sub-domain of Augmented Reality that does not require equipping users because the composition of the real and virtual worlds is performed through video-projection on physical surfaces [5]. Depending on whether the projection is made as a perspective view for a trompe-l’œil effect or as a texture overlay for physical world texturing, the position of the onlookers has to be controlled or not. This mode of visual augmentation of the real-world is better suited for art applications than through worn devices because it allows visitors to enter freely in such installations. Viewers can move around as long as they stay close to the appropriate viewpoint if the installation is using perspective effects. In the case of texture overlay, viewers can freely choose their point of view. In the case of outdoor installations, since they are based on video-projection, SAR installations can only be seen at night.

In the case of fixed SAR installations, the registration (spatial alignment of physical and virtual elements) can be made manually with the video-projector located in its final position. If the viewers must be located in a fixed position with respect to the projected surface, their view can be constrained by watching the scene from a keyhole or a platform like in the ancient panoramas [8]. The scope of objects on which SAR applies is large and can consist of prepared surfaces such as small scale models of buildings, cars, sculptures painted in white... or non-prepared surfaces such as storey houses, industrial remains, historical buildings, exhibition places... with or without colorimetric compensation to dim the color of the projected part of the surface.

Registration in Augmented Reality installation is the cor-
resonance between digital information overlay and the physical world. Registration accuracy is particularly crucial if overlaid information is semantically related with the physical world components such as building or shop names in an urban environment [9]. Registration mostly relies on camera calibration and image analysis for physical components identification, tracking for viewer’s position acquisition, information access for real/virtual world correspondence, and compositing for visual or auditory information overlay. In the case of SAR, registration and stitching must be very accurate because of the morphological correspondence between the projected image and the real-world [5]. The human eye detects very well color contrasts and boundaries, and is therefore very sensitive to mismatches between video-projection overlay and projected surface morphology.

1.3 Scientific and Technological Areas

To sum up the preceding discussion, the Bateau Ivre installation belongs to the domain of non-equipped Mobile Augmented Reality through real-time video-projection overlay for SAR. Since the digital augmentation of the real-world results from special effects applied to the live video capture of the physical environment, registration amounts to the calibration and registration of a video capture with the captured zone.

Mobility and SAR have been addressed in studies in the framework of tangible interfaces. The phicons (physical icons) in such interfaces are mobile objects with a known geometry that are visually augmented through multi-projection and registered through recognition and tracking. In Dynamic Shader Lamps [2], children can use virtual painting tools to decorate tracked video-projected white objects and move them around as long as they stay into the multi-projection lighting area. Tracking and known geometry could be avoided by using camera-based techniques to acquire and track the objects. In the case of an augmented deformable object for which accurate geometrical details must be known, real-time scanning provides the system with more accurate geometry to adjust dynamically virtual augmentation to the changing shape [16]. Many other such interfaces have been developed since. They use deformable and/or mobile objects in the physical space as interaction devices.

Another way of coping with mobility in the case of SAR is to adapt the projection to the projected surface in the case of a mobile surface and/or a mobile projector. Enhanced projectors with image analysis capacities such as iLamps [19] can align texture overlay projection with the surface for various orientations of the projector. In this case, the surfaces must be equipped with markers to be localized properly. Scanner based solutions could be used alternatively and avoid markers.

Besides mobile SAR based on painted mobile objects or scanned surfaces, we are not aware of experiments of mobile SAR installations on non-equipped environments except the MobiSpray project [20] presented in the next section. The Bateau Ivre installation belongs to the current trend of Augmented Reality for the public or semi-public spaces that covers various types of installations: pervasive games and performances (such as Can you see me now by Blast Theory [4]), interactive façades (such as [6]), augmented tour guides (such as Walk through Pompeii by LifePlus EU Project[26]), public space broadcasting or advertising (such as Vlahakis [15]), architectural and urban design (such as Rethinking the cities of Turin and Milano in [13])... We now examine some of SAR environments that are oriented towards artistic expression.

1.4 Related Artistic Works

The combined availability of cheap powerful video-projectors, high performance graphic boards for gamers, and real-time 3D engine have boosted the development of SAR artworks, whether in the urban space or on indoor prepared surfaces. We review some of these works, and subdivide them according to 4 binary features: perspective/overlay projection, prepared/non-prepared surfaces, static/mobile, and interactive/prerecorded.

One of the major trends in SAR artworks is the combination of video-projected and physical architecture. In the case of texture overlay, the combination is often a superimposition of a virtual morphology upon the existing one such as [7]. In this installation, a simplified 3D model of a historical cloister is overlaid on the building together with lighting effects. The visual effects underline the geometry of the building and result in an interesting mixture of contemporary line-based visualization and historical architecture. In the case of anamorphic perspective projection, the modification of the building façade amounts often to an extrusion and/or displacement of existing volumes as if the building structure had been post-edited. The virtual architecture modification trend is perhaps the most represented in the urban screen oriented artworks [13, 22]. Examples of such installations include [1, 23, 24]. It is interesting to note that all these works highlight their geometrical effects through virtual lighting and strong cast shadows. Pablo Valbuena even gives the illusion in his Augmented sculpture presented at Ars Electronica in 2007, that some of the volumes of the prepared white surfaces could be luminescent by adding some global illumination effects to the selective lighting of sub-volumes.

Interactivity is an interesting issue in urban SAR artworks (and in urban screen installations in general) because it can be a means to give some control to the audience, and also a tool for connecting the course of the installation to other surrounding events (noise, temperature, car flow, passersby). For example, the visual part of the Organ and Augmented Reality installation designed by Bertrand Planes was registered to the pipes of the organ, and consisted of LED-like visuals that were controlled by a real-time capture of the organ sound [11].

The control by passersby can be passive and seen without specific equipment as [12], where the shadow of the onlookers is used to reveal videos that are projected into the dark shadowed parts of the ground. Human control can be indirect and based on the analysis of human group activities such as social networking. For example, the Janus facial anamorphic projection [3] was a shape face based on an analysis of network communication in the city. More direct communication generally involves hand-held devices whether given or possessed by the audience as in the large-scale Pong game on the Haus des Lehrers building [6].1 In the case of non-

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1 The Pong game is based on real window lighting, and therefore is not a genuine Augmented Reality installation. We however review it here because the resulting effect is very close to what could have been made through SAR. This example interestingly blurs the frontiers between Augmented Reality and physical installations.
pre-existing graphics, the control of the drawing can be directly given to the audience or an artist as in MobiSpray live building painting [20]. This environment is made of a portable video-projector, a laptop, and a mobile phone. The phone is used to control simple interactive drawing video-projected on the buildings. In this installation, no registration is required because the alignment of the graphics on the geometry only relies on the skill of the “painters”, and on the accuracy of the painting device.

SAR is a difficult issue in mobility because of the required registration and, to the best of our knowledge, it has not yet been addressed in visual arts except for the specific case of MobiSpray project [20] presented above. Conversely, Mobile Audio Augmented Reality installations have already been designed such as [21], but audio registration requires much less accuracy than the visual one. Our approach to Mobile Augmented Reality through the use of captured image as a base component for augmentation has greatly simplified the registration issues, and allowed correct registration without fiducial markers in the physical world, and without viewer’s tracking requirements.

2. RENDERING PLATFORM

The Bateau Ivre installation was carried by a ship on the River Seine. The ship was divided into a setup area with all the equipments and a public area for the audience who was viewing the mobile art installation. The technical part consisted of lighting equipment for infrared (IR) projection, video cameras for capture, real-time graphics for special effects, and video-projection on the River banks. The ship was travelling along the River at a distance of approximately 20 meters of the River banks.

2.1 General Architecture

We now describe the physical installation and software components, and provide details on the shaders used in multipass Graphic Processing Unit (GPU) programming.

2.1.1 Physical Installation

The real-world environment (River bank and buildings overlooking the River) is lit up by IR light provided by four powerful theater spotlights equipped with an IR filter (to block visible light). This illumination allows a pair of IR sensitive camera to capture an IR image of the lit zone while avoiding visual feedback because the light spectrum of the video-projector is above the IR range.

Each camera is connected to a graphic workstation running a 3D rendering engine with an nVidia Quadro FX 3700 to process and render live images at 25 frames by second. The 3D engine uses live video image analysis for synthesizing special effects. The resulting image with its special effects is overlaid on the River banks by four projectors (two for each computer). Output image is modified in real-time by the artist through the control laptop used to select and parameterize visual effects (Figure 3). Real-time control relies on the dynamic modification of the multipass graph architecture (dynamic modification of the pile of effects) and on the modification of the parameters for each effect.

2.1.2 Software Architecture

The Bateau Ivre installation relies mostly on two components: a 3D rendering engine with GPU programming for image processing and special effects, and a Graphical User Interface (GUI) for real-time control of these effects by the artist. The software architecture is distributed on three computers. It is composed of 2 standalone applications connected through UDP messages.

The first application is Virtual Choreographer (VirChor) [25], an XML specification language and a tool for modeling and animating graphical and sonic objects. The tool is well-suited for artistic design and interactive 3D scenes. It allows high level OpenGL computations, combined with GPU programming and UDP network communication for the control. Open Sound Control (OSC) is an efficient encoding of data for UDP messages that is well appropriate for art installations. VirChor obtains live IR video images from each camera. The images go through a multipass graphic pipeline (Figure 4). The visual aspect of each special effect is controlled by a set of parameters (color, thresholds, sensitivity factors...).

The next section explains how the graph of effects is designed to enable easy shortcutting and live selection of active special effect stack.

The 3D engine VirChor was designed to facilitate GPU programming through XML attributes. Standard offline iterative algorithms can be used to improve IR image quality through image smoothing and restoration (noise removal, intensity stabilization, or contrast enhancement), but they require a significant processing time. Obviously, such processes cannot be used for interactive live video processing. Implementing such algorithms on GPU accelerates computations to achieve real-time or near real-time image processing. GPUs are highly parallel processors and therefore provide a benefit/computing cost ratio 10 to 50 times better than us-
The live video image is deinterlaced through a space filter (adapted to moving images). At each frame, a half of the lines of the captured image are computed from the other half of the image. We use the following formula where \( p_{i,j} \) and \( P_{i,j} \) respectively represent the brightness of the input and output pixels at \( i^{th} \) row and \( j^{th} \) line:

\[
\text{if \ } j = 2n+1 \ \ P_{i,j} = 0.5 \times (p_{i,j-1} + p_{i,j+1}) \ \ \ \text{else} \ P_{i,j} = p_{i,j}.
\]

### 2.2.2 Contrast and Brightness Correction Filter

The contrast correction enlarges the brightness interval by applying a brightness threshold function shown in Figure 6.

![Figure 6: Contrast Correction Function.](image)

Brightness correction adds or subtracts a fixed brightness value: \( \text{Brightness}_{i,j} = P_{i,j} + \text{BrightnessValue} \). The contrast and brightness functions are arbitrary simple (linear functions) to make them intuitive, easily learned, and controlled in real-time by an artist.

### 2.3 Image Rendering

The image rendering part deals with artistic special effects based on image filtering techniques.

#### 2.3.1 Sobel Edge Detection and Contouring

The Sobel algorithm computes a discrete differentiation operator, an approximation of the gradient of the image intensity function. It is assumed that the real environment edges correspond to high variation of intensity because they are associated with figure/background frontiers. The two following matrices describe the vertical (\( G_y \)) and horizontal (\( G_x \)) local masks that are applied to each \( 3 \times 3 \) square group of pixels around the rendered pixel to detect contours through brightness variation computation.

\[
G_x = \begin{bmatrix}
+1 & 0 & -1 \\
+2 & 0 & -2 \\
+1 & 0 & -1 \\
\end{bmatrix} \quad \text{and} \quad G_y = \begin{bmatrix}
0 & 0 & 0 \\
-2 & 0 & 1 \\
-1 & 2 & -1 \\
\end{bmatrix}
\]

As a second approach to contouring, the local variation of intensity value is the average absolute difference between the pixel intensity value and its neighbor values:

\[
P_{i,j} = \sum_{n=-1}^{1} \sum_{m=-1}^{1} |p_{i-n,j-m} - p_{i,j}|.
\]

On top of gradient computation, a brightness threshold is applied to the resulting image and produces the expected contouring effect (Figure 7). It is used both in rendering as a visual effect and in particle animation (so that particles collide against real-world edges).
2.3.2 Color Sub-sampling

This effect produces a non-realistic cartoon-like shading. The fragment shader reduces the number of sampling values for pixel colors through a transfer texture that maps continuous light values in \([0,1]\) to a set of discrete values. We use the following texture (Figure 8) for sub-sampling at different levels. Each level is associated with a number of sampling values (between 2 and 8) evenly distributed between black and white.

![Intensity Sub-Sampling Texture](image)

**Figure 8: Intensity Sub-Sampling Texture**

2.3.3 Spatial Sub-sampling (Blur)

The spatial sub-sampling method used is a combination of image scaling transformations. This down-scaling/up-scaling technique produces a blur effect through minimal computation time and texture access. Pixel brightness value interpolation is automatically performed within the GPU during up- and down-scale due to graphic board interpolation capacities and results in the expected blur effect (Figure 9).

![Bluring through Down- and Up-scaling](image)

**Figure 9: Bluring through Down- and Up-scaling**

2.3.4 ASCII Shading

ASCII art consists in creating an image with ASCII characters. The ASCII shading filter substitutes rectangular tiles of the original image by ASCII characters based on a match between the brightness of the pixel block to replace and an ASCII character. To compute the average brightness value of each pixel block, the original image is down-scaled so that one pixel of the shrunk image corresponds to one ASCII character.

The ASCII texture contains 76 ASCII characters sorted by brightness. Since each character is an 8x8 pixel square, the image is down-scaled by a factor 8 to obtain one pixel for each substituted ASCII character. Figure 10 shows an ASCII shaded image (right) and the corresponding original image (left).

![ASCII Shading Effect](image)

**Figure 10: ASCII Shading Effect**

2.4 Real-Time Particle Animation and Rendering

In addition to previous image processing effects, we implemented two particle systems with the same dynamics and different visual effects. Particles have an initial speed and are not damped. They bounce against borders provided by the contouring filters (see section 2.2) and possibly leave the screen when they reach a border.

Particle dynamics is computed in the GPU using a multipass pipeline. In order to store position and velocity of all particles, we use two float32 Frame Buffer Objects. The first shader uses the particle data textures and border detection texture to compute particle trajectories. Then, a second shader creates particle sprites and stores the resulting effect into a particle rendering texture. This latter texture is either displayed directly or enhanced through various post-processing effects, e.g. visual feedback effects, image distortion, or image colorization. Figure 11 shows how particles are integrated into the global image synthesis architecture.

The computation of particle dynamics is based on three main rules. First, particles fall under the vertical gravity force. Second, when they hit a border, particles bounce back either horizontally, or vertically, depending on horizontal or vertical tests. If a particle hits a border, we test the pixels around the particle position to classify the border as vertical or horizontal. Based on the output of these tests, the velocity is inverted vertically on horizontal borders, or horizontally on vertical borders. The third rule keeps particles on screen. When they fall under the screen area, particles
are set back on top of it. When they reach the left or right side of the screen, particles loop as if right and left borders were merged. A particle getting out the frame from left will reappear on the right.

The first type of particles is rendered through sprites and real-time effects are added to the output image. For example, Figure 12 shows a combination of sprite-based particle rendering with visual feedback effect.

The second type of particle rendering uses the image of the particles as a generator of special effects that modifies the live video image. Figure 13 illustrates two effects produced by using the color buffer of the rendered particles to transform the live video image. On the left side, the particle color is used to modify the color of the output in the contouring filter. On the right side, the particle buffer is used to modify texture coordinates in the fragment shader and, thus produce a distortion of the video image. Each particle behaves as a lens moving over the image. Particles width can be dynamically edited through the control interface. Thus, their influence on image deformation and colorization is modified dynamically.

2.5 Compositing and Control

All our algorithms are based on intensive GPU processing. VirChor is used to create the OpenGL scene, associated with Cg shader programs to perform image processing and rendering. VirChor also enables network communications with the GUI, and redirects the values of the widgets into shader parameters and scene structure. Thus, the artist can dynamically enable or disable some effects and set effects parameters through an external control application.

The control GUI is implemented in JAVA, and sends UDP-OSC messages to VirChor (see Figure 14). Apart from activating or deactivating some effects, the interface is also used to control shader parameters such as special effect transparency, blur radius, pixellization size, number of sub-sampling values, contrast, colorization...

The main benefit of the GUI modularity is to enable using several computers for 3D rendering and image processing with a single GUI that control them all by broadcasting network messages. The computer, running the Java interface, thus controls in real-time the two 3D rendering and image processing applications.
3. ANALYSIS

The software developments and hardware configuration presented in the preceding section were used to perform four occurrences of the Bateau Ivre artistic installation during the Futur en Seine festival (4 times 45° during the night of June 5, 2009). The installation was embarked on a vessel along the Seine River and the audience could view the video-projection from the right side of the boat. During the trip the artist was controlling the rendering by selecting and parameterizing one or more of the 12 available special effects: negative image, pixelization, Sobel edge detection, wireframe contouring, spatial sub-sampling, color sub-sampling, ASCII shading, contrast, kaleidoscopic effect, particles, plasma effect, or colorizing (Figure 15).

3.1 Technical Achievements

The main outcomes of the project are:

- The capacity of producing real-time multi-layer special effects on top of image correction through GPU-based multi-pass rendering. The main challenge was to ensure that the lag time between camera image capture and video-projection of the composited effects was compatible with ship motion.
- The design of a GUI for artistic control. Its role was both to dynamically reconfigure the pile of effects and to finely tune the effects so that they would meet the artist’s needs.
- The capacity of providing powerful IR lighting of the River banks through regular theater spotlights without visual feedback effects. The combination of this lighting technique together with regular video camera equipped with IR filters showed that a good quality nightly IR capture can be ensured without specific and costly equipments. The only high range equipments in this installation were the two pairs of video-projectors so that rendering could be visible in both dark and enlighten River bank areas.
- Because of the use of regular video equipment and spotlights (instead of genuine IR cameras and projectors), the captured IR video image were noisy and blurred. Despite the low quality of the monochromatic IR image, it was however possible to implement a wide range of creative special effects through combined image correction steps and a pile of image filtering steps.

3.2 Discussion

Despite the successful achievements of the Bateau Ivre project, we are aware that Mobile SAR is a complex task for which we have only addressed some of the technical and scientific issues.

- The difficulty of registration is due to the combined complexity of SAR registration and mobility. SAR requires a strict morphological correspondence between the digital projection and the physical world that has to be maintained whatever the speed of the vessel and its possible rotations. A standby pause in front a building with a complex architecture was made by the boat at the beginning of each trip to recalibrate the system through software image distortion. Stricter calibration would however have been necessary for a better registration.
- Double video-projection (through coupled video-projectors) was used to enhance the brightness of the projected effects. Because projected surfaces were located at variable distance, and because the lenses of the projectors were separated by approximately 50 centimeters, the two projected images could not be focused for the whole range of projection distances. An optical system with mirrors that would have joined the two light beams would have solved the variable distance light convergence issue; it might however reduce the light beam intensity.
- Apart from one capture test on a moving car, the whole development of the installation was carried out in a laboratory environment. Some of the effects that distorted the geometry of the image were looking very nicely on a computer screen, but did not have such a visual impact when projected on the real-world environment. We discovered that the registration between the effects and the physical world morphology has to be preserved to keep a good understanding of the video-projection by the audience. In particular, effects with blur or geometrical distortion should be avoided in SAR based on image filtering.

The participants to the event reported that the environment had made them experience a nice immersive feeling because it preserved, and even outlined the morphology of the real-world. The contrast enhancing effects were the most striking and appreciated parts of the performance. The Bateau Ivre installation shows that simple image processing technique such as edge detection or contouring can have a big impact when projected on the physical world. Particles were also much appreciated because of their motion connected with the morphology of the River banks. For example, particles bouncing on the edges of concrete silos were reported as a very impressive effect. Symmetrically, all the effects that were distorting or blurring the captured image were not appreciated because of the decorrelation between the synthesized effects and the real-world shapes.

4. SYNTHESIS AND PERSPECTIVES

Despite some technical inaccuracies, the Bateau Ivre installation offers a new approach to SAR by allowing for mobile installations through real-time special effects. The main components of the application are lighting, registration (that amounts to calibration in this case), real-time image processing and synthesis, and output convergence (in the case of multiple video-projectors for a single projection). Our work pushes a step further the now quite common SAR lighting of historical buildings by introducing mobility and interactivity.

Among the perspectives of this work for mobile SAR are:

- calibration (morphological registration) could be improved through a preliminary standby position in front of an architecture equipped with a few markers,
- the tracking of the real-world elements combined with depth measure could allow to composite the live video capture with 3D elements. This would enable addition of virtual 3D components, with coherent lighting
and shadowing, as well as the transformation of the geometry such as addition of holes, fake components, or modifications of the building structures,

- the scenario, behavior, and blending of the real and physical world could be made more complex since the installation can be controlled both through live interactions and predefined event sequences. For example, network communication between such a software environment and other applications could be used for sound-based control in the case of sound analysis,

- the physical system could be optimized and improved by adding specific optic equipment for beam multi-depth convergence,

More generally, the system is a successful starting point for a creative approach to real-world live and mobile enhancement.

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6. REFERENCES

Figure 15: Six Visual Effects Seen from the Boat During the Trip.