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# Hologram based Internet of Signage Design Using Raspberry Pi

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## [Abstract]

This paper propose design of remotely controllable hologram based interactive signage. General idea is organization of work of hologram signage through using Raspberry Pi hardware platform and Intel realsense r200 for interaction opportunity. Remote content management is based on Screenly software solution. Open CV based solutions are used for content controlling on the spectators side. Represented work describe of using of the 3D content rendering algorithm based on 3D gaming technology Unity 5. An experimental model was carried out with the purpose of IoS designing, to 3D data visualization and to introduce a new method for visualizing and displaying 3D data on a hologram pyramid signage. Description of working model of hologram signage is given in this paper.

▸ **Key words**: Signage, Screenly, Hologram, Camera, Motion control

## [요 약]

본 논문에서는 원격 제어 홀로그램 기반 인터랙티브 사이니지 디자인에 대해 제안한다. 제안한 방식은 Raspberry Pi 하드웨어 플랫폼 및 Intel realsense r200 카메라를 사용하여 인터랙션이 가능한 홀로그램 사이니지 구조를 구성하였으며, 소프트웨어 파트는 원격 콘텐츠 관리를 위한 Screenly 솔루션과 콘텐츠 제어를 위한 Open CV 기반 솔루션을 기반으로 구성된다. 3D 게임 기술 Unity 5를 기반으로 한 3D 콘텐츠 렌더링 알고리즘을 사용하여 테스트를 진행하였으며, 홀로그램 피라미드 사이니지 구조를 사용한 모델 테스트를 통해 IoS 설계를 위한 3D 데이터 시각화 및 표출이 가능한 새로운 방식을 실험하였다. 본 논문에서는 해당 홀로그램 사이니지 모델에 대하여 기술하였다.

▸ **주제어**: 사이니지, 스크린, 홀로그램. 카메라. 모션 제어

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## I. Introduction

Moving in step with technological progress, we not only successfully use ready-made digital solutions, but also develop our own interactive software, which our customers need to achieve their goals. These programs are designed for touch kiosks or panels that solve the task of presenting digital content. This equipment greatly simplifies the work of specialists from different industries to provide the audience with any information - teaching, presentation, analytical. In addition, it is widely used for advertising purposes. Digital Signage is a visual representation of information on digital media (screens, stands, displays, etc.) located in public places. Digital Signage is an indispensable marketing tool in offline sales and is characterized by a high return on investment. Integration of the system is relevant in all areas of business and is able to solve various design tasks. The use of interactive self-service kiosks in recent years is very popular with many retailers offering various goods and services. Ubiquitous adoption of technology makes it possible to implement digital kiosks in a shorter timeframe than it was in the case of ATMs and mobile phones.

But standard kiosk and digital signage today is slowly pushed out by holographic solutions. Holograms today is a brand new technology used as digital signage. They earning their points of authority in exhibitions, shopping malls, media centers etc.

In physics, holography is a special photographic method, in which first the 3D images that are as close as possible to real ones are recorded and then restored. When illuminated with holograms form an exact 3D clone of the object and copy its properties. For example, changing the perspective when moving the viewer. Holograms allow you to reflect objects in three-dimensional space even without the use of special glasses[1]. This image can be used in presentations, business events, in museums, in flagship stores - wherever interaction with the object is important. But for nowadays this types of holograms are still prototypes.

## II. Preliminaries

### 1. Related works

A Projection System for Real World Three Dimensional Objects Using Spatial Light Modulators U. Gopinathan, D.Monaghan, B. Hennelly, C. Mc Elhinney, D. Kelly, J. McDonald, T. Naughton, and J. Sheridan[2]. An algorithm to encode the digital holograms of real world objects on to an SLM is presented. The project present results from experiments to project holograms of real world holograms using a sematic liquid crystal SLM. We discuss the case when the pixel sizes of the charge -coupled device (CCD) and SLM used for recording the hologram and projection are different. Index Terms —Holography, liquid crystal displays, spatial light, modulators, three-dimensional (3D) displays. The above paper uses LCD for projection of hologram. In interactive holograms we are going to use an LCD along with hardware sensor which will be synchronized with system to make changes as per user's gestures.

Improved Hologram Calculation for Correlated Video Frames M. Bernau[3]. This paper presents an algorithm for real-time calculation of computer generated holograms. The proposed algorithm is especially designed for highly correlated video frames as it uses the hologram of frame n as initialization for the calculation of frame n+1. Application is laser-based projection for handheld devices or head-up displays. This paper focuses on the correlated video frames where the calculation of computer generated hologram is done. The technique used here for hologram projection is laser but the interactive holograms will include projection of hologram using Pepper Ghost Technique.

Real-time Integral Photography Holographic Pyramid using a Game Engine S. Anraku, T. Yamanouchi and K. Yanaka[4]. This paper describe the solution for the holographic pyramid system that can display an animation of integral photography images that appear to be floating is developed using a game engine and by writing its shader. An animation of the object, as viewed from

the front, rear, left, and right, are displayed on the four surfaces of the pyramid. The user can control the object rotation using the keyboard.

Suggested in current paper solution is unite of some existing methods of hologram application as a signage and adding the system of local and remote controlling of content management. Benefits of using solutions of Screenly is opening easy way of remote controlling of small and cheap solution based on Raspberry Pi hardware. As for the interactivity, current concept uses Intel realsense r200 for interaction with signage hologram spectator. Interaction is provided by possibility of using hand gesture of air swipe from right to left and left to right, same as media content changing on smartphone.

## III. Use of a unity 5 and camtasia studio to create 3d hologram content

Using game engines such as Unity 5 helps to avoid necessity to use classical methods of 3D hologram content creation[4]. When you needed to use a least 4 positions to make a 4 side view pictures of one object[5]. Unity solutions allow to create 3D models of needed content and set side views inside the working environment to make a video record of the 3D object. Next step of the creation of the 3D content is “gluing” four sides of 3D object recorded picture in to one video frame. For our solution we used “Camtasia Studio” software. Content preparation activity diagram is shown on Figure 1.

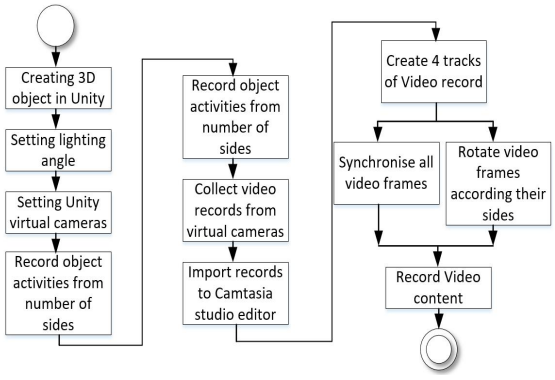


Fig. 1. Content preparation activity diagram

Unfortunately this solution is not applicable to be used on the Raspberry Pi hardware, because of the limits of the processing units. So all content was prepared and preloaded to the Raspberry Pi module through wi-fi network.

## IV. Playback management of the content

Usually you can upload video files to directly via a flash drive, or connect the device to the LAN and update the files on it on the network. Control over the playback of content is also carried out over the network. For our solution we used “Screenly Open Source Edition” - a platform that allows to create, manage and distribute content in digital display networks. Screenly OSE is a digital signage solution powered by Raspberry Pi. It allows users to display videos, web content and images on TV screens. Screenly can be used to display advertisements, live dashboards, system statuses and in-store video advertising. The software allows users to manage multiple screens through a single web interface. It provides features like video encoding and local caching, and can also store video and image content in the Screenly OSE cloud. Users can check the status of display nodes, including node uptime and connectivity status. Screenly allows users to create playlists for a single screen or multiple group screens.

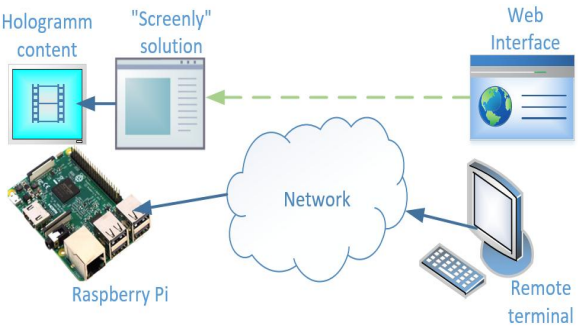


Fig. 2. Content control sub-system structure

Digital signage platform - Screenly provides management of small as well as large systems of retail trade, educational institutions, transport and

commercial organizations. The player based on Raspberry Pi allows users to play HD video, images and web pages; provides security checks and remote status monitoring. Screenly system offers CMS and API, so it can be used stand-alone or integrated with IoT systems (including start-up sensors), as well as with larger and more complex Digital Signage systems.

Controlling interface of Screenly is intuitively clear, we can control our content through web interface.(Figure 3.) Scheduling system allows us to manage content by time of displaying, duration and dates. Content also could be published on dynamic changeable resources through special modules. Such as a Screenly Cast for WordPress [6]

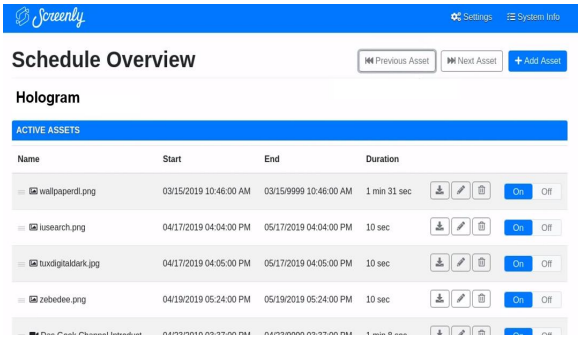


Fig. 3. Screenly schedule system

Also it is possible to make special 3D widgets on java script to provide public useful information as time, date, weather broadcasting or bus schedule, etc.

## V. Implementation And Analyses

The signage in this work is based on Pepper's Ghost technique, which used a display as a projector for displaying our enhanced 3D object. The pyramid was built with four sides, and the projector was placed on the top of the pyramid. A three-dimensional virtual signage is a pyramid for demonstrating realistic three-dimensional objects. The device allows to achieve the effect of a hologram “flying” in the air: to demonstrate a three-dimensional virtual image, as if moving inside a glass pyramid (Figure 4.). 3D-pyramid makes it possible to view any object from different sides, as if it were presented in a display case [7].

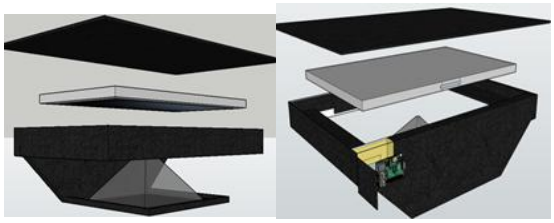

Fig. 4. 3D Model of proposed hologram signage stand

The object inside the display case can be changed or rotated to provide a better view. Our solution for this is to use the Intel realsense r200 camera to capture and recognize hand motion of spectator[8,9]. Activity diagram of this process is demonstrated on Figure 5. For this solution OpenCV library was used [10,11].

This technology also allows to combine imaginary three-dimensional images with real objects. For example, you can put a real glass in the device, which will be filled with a virtual drink, accompanied by fireworks or other bright visual special effects. The image that the viewer watches on the hologram is formed by specially prepared video content[12]. The technology of video animation allows you to demonstrate everything inside a glass prism, however, any video needs adaptation for demonstration.

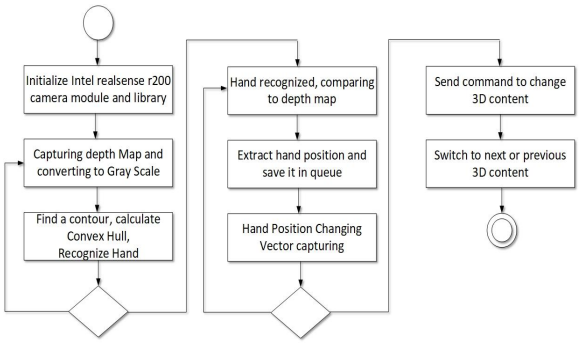


Fig. 5. Hand motion Content control activity diagram

Motion detection algorithm is focusing only on capturing of the hand motion. And making a detection of the hand air sweeping from the left to the right or from right to the left. We used an

existing typical algorithm for motion detection, with modifications to simplify for our needs.

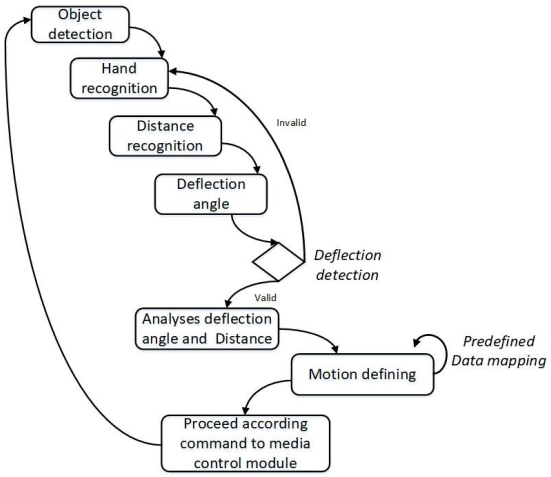


Fig 6. Hand motion detection Algorithm in State Diagram

The state diagram of working hand motion detection algorithm is shown on Figure 6. When an image is detected by camera, a smoothing operation is performed to remove noise by The Gaussian kernel. Then, objects are separated using the binarization technique. Initially camera detect only distance and a deviation (deflection angle) from the normal plane of the camera. And a specific task was binded to each distance and hand position. As for main target was the developing of interactive hologram signage with remote control opportunity, the realization of gesture recognition algorithm made with primitive "swaping motion" capturing only.

Multi-party interaction opportunity was not realized, so all testing results are made for one person standing in front of the camera. Testing results of working distance are shown in a Table 1.

Table 1. Hand motion capturing test results

| Distance | Motion detection time | System response time | Total delay |
|---|---|---|---|
| 0.5 m | 800 ms | 300 ms | 1100 ms |
| 1 m | 400 ms | 300 ms | 700 ms |
| 1.5 m | 400 ms | 300 ms | 700 ms |
| 2 m | 800 ms | 300 ms | 1100 ms |

As shown in the table the optimal distance for use hologram content control is 1-1.5 meter.

This hologram was conceived as a device that allows you to display pseudo-3D movies. Therefore, if you want to show a video with an object, you need to ensure that several conditions are met. The most important moment - the object should be located on a black background, only this way it is possible to achieve the effect of its soaring in the air. In addition, the object must either rotate in vertical axis [3]. If you want to show a normal video on such a hologram, then, unfortunately, all the advantages of the device couldn`t be achieved. If the video has clearly defined rectangular borders, then when it is shown, it is perceived as a strange display with a flat screen. To achieve the best effect, the video content for the hologram should be prepared in accordance with the recommendations in [13].

Constructively hologram is should be projected by 1080p screen with high illumination level. The screen resolution is determined by the software which we are using [14,15]. Hardware controller based on Raspberry Pi 3 B and working under Screenly software solution. To create a prototype we used a 7 inch Touchscreen Display for Raspberry Pi. The 800x480 display connects via an adapter board which handles power and signal conversion. By the reason that Screenly solution is based on Raspbian OS, display and touchscreen started working with no issue.(Figure 7.)

Fig. 7. Scaled model of hologram digital signage

Stand of the prototype was printed on 3D printer,

and pyramid reflector is made from acryl. Prototype had some problems in demonstrating various types of content according the screen resolution of 7 inch Touchscreen Display for Raspberry Pi. After changing this display to the high resolution monitor, all content display problems disappeared.

For the final design we used 65% transparent film attached to the glass made pyramid. It reflects the image from the source which is 46 inches LCD Display. All frame was made from steel angles and covered by dark toned plastic. In the middle of the frame Intel realsense r200 Camera Module was installed. This module are helping to interact with demonstrating hologram by hand actions. For the current solution we implemented just content changing option, by air sweeping.


Fig. 8. Final prototype of hologram digital signage

Implementation of 3D Hologram for organization Internet of Signage concept made as it shown on Figure 8, on the top of the hologram stand the device was placed. The hologram pyramid made of semi-transparent tanned glass. The stand base made of steel angles, according the weight and hardness of the construction.

## VI. Conclusions

Technical applications are represented by holograms used in medicine, engineering, architecture, and retailing. Conception of using hologram as the signage is mainly limited only by conditions of environment and content processing. This solution allows to demonstrate HD quality content. Raspberry Pi as a low cost solution provide possibility to demonstrate prepared content, but content rendering should be made on more powerful devices with GPU. Otherwise we are losing the smooth of work. Organization of IoS itself on the Raspberry Pi 3B has no limits due it support Ethernet and Wi-Fi. Remote and local controlling of content nowadays is have no limitation and supported by various types of hardware and software solutions. Organization of IoS Network security should be applied according the required level, here VPN solutions is more preferable. Raspberry Pi in tandem with Screenly solution showed great results, which justify our expectations.

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