

AUDIO POINTER – JOYSTICK & CAMERA IN MATLAB

F. Rund

Department of Radioelectronics, Faculty of Electrical Engineering,
Czech Technical University in Prague, Czech Republic

Abstract

A virtual sound source can be positioned in virtual auditory space with various methods, as shown in our other articles. There are many applications of virtual sound source positioning, e.g. as assistive technology for helping blind people to orientate in real space. In the case, an operator can watch video simulating vision of sighted people and create the virtual sound source which navigates direction of user's walk. An appropriate positioning device (e.g. joystick) has to be used for determining the direction. The paper is devoted to simple implementation of the system in Matlab. The picture from user's camera is shown, an operator have to point the joystick in direction, where virtual sound source have to be generated in users headphones. This implementation is used for design of the system and testing the algorithms for virtual sound source positioning.

1 Introduction

Virtual sound source positioning methods can be used for various applications, e.g. in computer games. This paper is considered on a Matlab implementation of a system, positioning a virtual sound source to a position determined by using of joystick. This implementation is intended for testing purposes of the PERSEUS (personal help for blind users) system [1].

The PERSEUS system consists of two parts – user's and operator's. The blind person (user) is equipped with stereoscopic camera, headphones and wearable PC which can communicate with the operator. In case of emergency, operator can see context of user's environment in 3D, so can estimate distance of obstacles. Thus he can navigate the user by means of acoustic cues, sent into user's headphones. An appropriate positioning device, e.g. joystick, is used for determining the direction.

Matlab implementation, described here, is devoted to the problem of creating and presenting sound coming from the direction which corresponds to position of the joystick.

2 Design of the system

The described system deals with two main problems. The first problem is to create virtual sound source in desired direction. The second problem comprises of reading of position of joystick and sending the appropriate sound to user's headphones. Solving of the problems is divided into two scripts, described below.

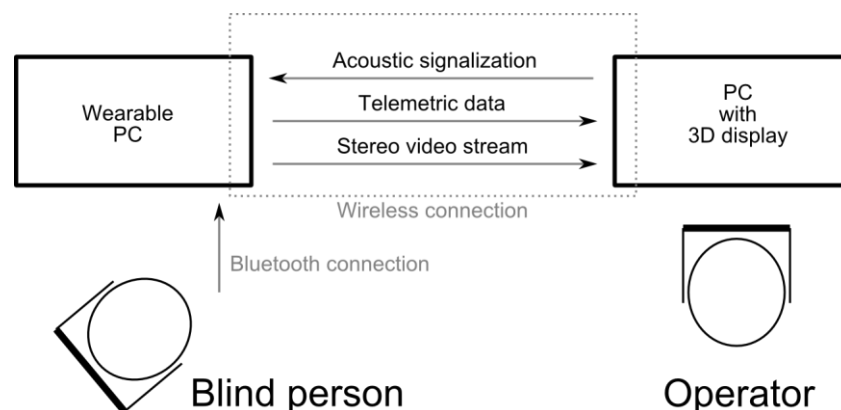


Figure 1: Arrangement of the PERSEUS system 0

2.1 Sound generating script

The first problem is how to generate virtual sound source, apparently coming from desired direction. As is shown e.g. in [2], for creation of a virtual sound source can be used the Head Related Transfer Function (HRTF). This function captures the spectral changes of a signal that occurs when a sound wave propagates from sound source to the listener's ear. The HRTF is by means of (inverse) Fourier transform connected with the HRIR (Head Related Impulse Response). The HRIR can be taken out by means of measurement, or can be also modeled (e.g. series of filters simulating effect of torso, shoulders, head, pinna...). It's possible to find more sets of measured HRIR's, the most complex is the CIPIC HRTF database [3]. As is known from theory of linear systems, an output signal of a linear system can be computed as a convolution of an input signal and the impulse response of the system.

In our script we at first use Matlab function `waveread` for reading the input audio file. For localization purposes is important to use wide band signal, for example set of clicks (castanets). The second step is to determine the desired spatial resolution. For first attempt was 5 degree resolution used, which corresponds with human spatial resolution. Next step is to load appropriate set of HRIR's. In the CIPIC HRTF database [3] is each set of data saved as `.mat` file, so standard Matlab load function can be used. Due to a fact, that HRIR data is not measured with uniform resolution; next step is to interpolate the data to 5 degree resolution (function `interp1`).

After that, the `conv` function can be used for computing the output signal. The whole set of output audio data, with 5 degree resolution is generated. The output matrices are saved in Matlab standard `.mat` files, one for left and one for right ear. Also `.wav` files are generated, using the `wavwrite` function.

Result of the script is two matrices (left and right ear), saved in `.mat` file. One row of the matrices represents sound of the corresponding direction (0 – 360, step 5 degrees).

2.2 Sound positioning script

Function of the second Matlab script is very simple – read position of the joystick, find sound for corresponding direction and play it through user's headphones. The operator sees picture from user's camera and can point somewhere with joystick, as seen in Fig. 2.

At beginning of the script, `.mat` file with matrices of directional dependent sound is loaded. The main part of the script is enclosed in while cycle. During the cycle, the image from user's camera (see section 3.2) or static image (for testing purposes, function `imread`) is read, then position of the joystick is detected (see section 3.1). Because position of joystick is expressed using Cartesian coordinate (x,y), the azimuth is computed (angle 0-360 deg.). The azimuth (angle) is rounded to 5 deg. resolution and corresponding row of the matrices of directional dependent sound (left and right) is sent to user's headphones (function `sound`). As seen in Fig. 2, the cursor mark is drawn in camera picture, blue for position in front of the user, red for behind the user position. The cycle is repeated until any joystick key is pressed.



Figure 2: Examples of the operator's interface. The position of the joystick is marked by the cross, the blue color means, that operator points in front of the user, red color means behind the user.

3 Joystick & camera in Matlab

The crucial problem of this work is to detect position of a joystick in Matlab and to use picture from user's camera. In this testing implementation we don't solve problem of data transfer, the user's camera and headphones and operator's screen and joystick is connected to one computer. In next subsections we have discussed possible and used solutions.

3.1 Joystick detection

The number one problem is to detect position of a joystick in Matlab. More solution is possible, for example that presented in [4], which uses Data Acquisition Toolbox for communicating with the joystick. Another, and simple solution, offers [5].

The solution in [5] consists in .dll (or .mexw32) file, which is placed in Matlab working directory. If this solution is used, in Matlab Workspace is created a variable (vector) which contains information about position of the joystick in Cartesian coordinates and about state of the joystick keys. So, it is possible to detect the position of the joystick.

3.2 Camera capturing

It is not necessary, in our simple testing implementation of PERSEUS [1] system, to capture image from real camera. For simple test can be used static picture loaded from disc. But, for more realistic simulation of PERSEUS, picture from a camera connected to the computer can be easily captured for example using the program VCAPG2 [6], which is again provided as .dll file.

4 Results

This Matlab implementation is used for design of the system and testing the algorithms for virtual sound source positioning. The described version works in horizontal plane only, but can be easily changed to 3D version. Presented implementation is very simple, of course, not working in real time, some latency is introduced, but for simple and rapid testing the virtual source positioning algorithms it provides good tool.

Acknowledgement

This work was supported by the Grant Agency of the Czech Technical University in Prague, grant No. SGS10/082/OHK3/1T/13 and the research program MSM 6840770014 of Ministry of Education of the Czech Republic. Presented algorithms use data from CIPIC HRTF database [3].

References

- [1] Vitek, S. - Klima, M. "PERSEUS - Personal Help for Blind User", *2010 International Conference on Applied Electronics*, p. 367 - 370, ISBN 978-80-7043-865-7, Pilsen, 2010
- [2] Štorek, D. - Glaser, O.: "Virtual Auditory Space for Visually Impaired Created with HRTF". *POSTER 2010 - Proceedings of the 14th International Conference on Electrical Engineering*. Praha: ČVUT v Praze, FEL, 2010, p. 1-4. ISBN 978-80-01-04544-2.
- [3] Algazi, V.R.; Duda, R.O.; Thompson, D.M.; Avendano, C. "The CIPIC HRTF database," *Applications of Signal Processing to Audio and Acoustics, 2001 IEEE Workshop on the* , vol., no., pp.99-102, 2001
- [4] Radbil, S. *Joystick Adaptor*. Matlab Central, last updated 26 Sep. 2001, <<http://www.mathworks.com/matlabcentral/fileexchange/798>>
- [5] Bodson, M. *Fun Control Experiments with Matlab and a Joystick*. Last updated 6 Jan. 2010. <<http://www.ece.utah.edu/~bodson/fun/index.html>>
- [6] Kazuyuki Kobayashi. *VCAPG2* Matlab Central. Last updated 12 Feb. 2003. <<http://www.mathworks.com/matlabcentral/fileexchange/2939>>