Zbornik 23. mednarodne multikonference

INFORMACIJSKA DRUŽBA

Zvezek H

Proceedings of the 23rd International Multiconference

INFORMATION SOCIETY

Volume H

http://is.ijs.si

IS 2020

Interakcija človek-računalnik v informacijski družbi

Human-Computer Interaction in Information Society

Uredili / Edited by

Veljko Pejović, Matjaž Kljun, Vida Groznik, Domen Šoberl, Klen Čopič Pucihar, Bojan Blažica, Jure Žabkar, Matevž Pesek, Jože Guna, Simon Kolmanič

7. oktober 2020 / 7 October 2020

Ljubljana, Slovenia

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Oblikovanje naslovnice: Vesna Lasič

Dostop do e-publikacije:
http://library.ijs.si/Stacks/Proceedings/InformationSociety

Ljubljana, oktober 2020

Informacijska družba
ISSN 2630-371X

Kataložni zapis o publikaciji (CIP) pripravili v Narodni in univerzitetni knjižnici v Ljubljani
COBISS.SI-ID=33206787
ISBN 978-961-264-200-6 (epub)
ISBN 978-961-264-201-3 (pdf)

PREDGOVOR MULTIKONFERENCI INFORMACIJSKA DRUŽBA 2020

Triindvajseta multikonferenca Informacijska družba (http://is.ijs.si) je doživela polovično zmanjšanje zaradi korone. Zahvala za preživetje gre tistim predsednikom konferenc, ki so se kljub prvi pandemiji modernega sveta pogumno odločili, da bodo izpeljali konferenco na svojem področju.

Korona pa skoraj v ničemer ni omejila neverjetne rasti IKTja, informacijske družbe, umetne inteligence in znanosti nasploh, ampak nasprotno – kar naenkrat je bilo večino aktivnosti potrebno opraviti elektronsko in IKT so dokazale, da je elektronsko marsikdaj celo bolje kot fizično. Po drugi strani pa se je pospešil razpad družbenih vrednot, zaupanje v znanost in razvoj. Celo Flynnov učinek – merjenje IQ na svetovni populaciji – kaže, da ljudje ne postajajo čedalje bolj pametni. Nasprotno - čedalje več ljudi verjame, da je Zemlja ploščata, da bo cepivo za korono škodljivo, ali da je korona škodljiva kot navadna gripa (v resnici je desetkrat bolj). Razkorak med rastočim znanjem in vraževerjem se povečuje.

Letos smo v multikonferenco povezali osem odličnih neodvisnih konferenc. Zajema okoli 160 večinoma spletnih predstavitev, povzetkov in referatov v okviru samostojnih konferenc in delavnic in 300 obiskovalcev. Prireditev bodo spremljale okrogle mize in razprave ter posebni dogodki, kot je svečana podelitev nagrad – seveda večinoma preko spleta. Izbrani prispevki bodo izšli tudi v posebni številki revije Informatica (http://www.informatica.si/), ki se ponaša s 44-letno tradicijo odlične znanstvene revije.

Multikonferenco Informacijska družba 2020 sestavljajo naslednje samostojne konference:

- Etika in stroka
- Interakcija človek računalnik v informacijski družbi
- Izkopavanje znanja in podatkovna skladišča
- Kognitivna znanost
- Ljudje in okolje
- Mednarodna konferenca o prenosu tehnologij
- Slovenska konferenca o umetni inteligenci
- Vzgoja in izobraževanje v informacijski družbi

Soorganizatorji in podporniki konference so različne raziskovalne institucije in združenja, med njimi tudi ACM Slovenija, SLAIS, DKZ in druga slovenska nacionalna akademija, Inženirska akademija Slovenije (IAS). V imenu organizatorjev konference se zahvaljujemo združenjem in institucijam, še posebej pa udeležencem za njihove dragocene prispevke in priložnost, da z nami delijo svoje izkušnje o informacijski družbi. Zahvaljujemo se tudi recenzentom za njihovo pomoč pri recenziranju.

V 2020 bomo petnajstič podelili nagrado za življenjske dosežke v čast Donalda Michieja in Alana Turinga. Nagrado Michie-Turing za izjemen življenjski prispevek k razvoju in promociji informacijske družbe je prejela prof. dr. Lidija Zadnik Stirn. Priznanje za dosežek leta pripada Programskemu svetu tekmovanja ACM Bober. Podeljujemo tudi nagradi »informacijska limona« in »informacijska jagoda« za najbolj (ne)uspešne poteze v zvezi z informacijsko družbo. Limono je prejela »Neodzivnost pri razvoju elektronskega zdravstvenega kartona«, jagodo pa Laboratorij za bioinformatiko, Fakulteta za računalništvo in informatiko, Univerza v Ljubljani. Čestitke nagrajencem!

Mojca Ciglarič, predsednik programskega odbora
Matjaž Gams, predsednik organizacijskega odbora

FOREWORD
INFORMATION SOCIETY 2020

The 23rd Information Society Multiconference (http://is.ijs.si) was halved due to COVID-19. The multiconference survived due to the conference presidents that bravely decided to continue with their conference despite the first pandemics in the modern era.

The COVID-19 pandemics did not decrease the growth of ICT, information society, artificial intelligence and science overall, quite on the contrary – suddenly most of the activities had to be performed by ICT and often it was more efficient than in the old physical way. But COVID-19 did increase downfall of societal norms, trust in science and progress. Even the Flynn effect – measuring IQ all over the world – indicates that an average Earthling is becoming less smart and knowledgeable. Contrary to general belief of scientists, the number of people believing that the Earth is flat is growing. Large number of people are weary of the COVID-19 vaccine and consider the COVID-19 consequences to be similar to that of a common flu dispute empirically observed to be ten times worst.

The Multiconference is running parallel sessions with around 160 presentations of scientific papers at twelve conferences, many round tables, workshops and award ceremonies, and 300 attendees. Selected papers will be published in the Informatica journal with its 44-years tradition of excellent research publishing.

The Information Society 2020 Multiconference consists of the following conferences:

- Cognitive Science
- Data Mining and Data Warehouses
- Education in Information Society
- Human-Computer Interaction in Information Society
- International Technology Transfer Conference
- People and Environment
- Professional Ethics
- Slovenian Conference on Artificial Intelligence

The Multiconference is co-organized and supported by several major research institutions and societies, among them ACM Slovenia, i.e. the Slovenian chapter of the ACM, SLAIS, DKZ and the second national engineering academy, the Slovenian Engineering Academy. In the name of the conference organizers, we thank all the societies and institutions, and particularly all the participants for their valuable contribution and their interest in this event, and the reviewers for their thorough reviews.

For the fifteenth year, the award for life-long outstanding contributions will be presented in memory of Donald Michie and Alan Turing. The Michie-Turing award was given to Prof. Dr. Lidija Zadnik Stirn for her life-long outstanding contribution to the development and promotion of information society in our country. In addition, a recognition for current achievements was awarded to the Program Council of the competition ACM Bober. The information lemon goes to the "Unresponsiveness in the development of the electronic health record", and the information strawberry to the Bioinformatics Laboratory, Faculty of Computer and Information Science, University of Ljubljana. Congratulations!

Mojca Ciglarič, Programme Committee Chair
Matjaž Gams, Organizing Committee Chair

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PREDGOVOR

Interakcija človek–računalnik v informacijski družbi je konferenca, ki jo organizira Slovenska skupnost za
proučevanje interakcije človek–računalnik. Namen konference je zbrati raziskovalce, strokovne delavce in študente s področja in ponuditi možnost izmenjave izkušenj in raziskovalnih rezultatov, kakor tudi navezave stikov za bodoča sodelovanja .

Tokratna, peta reinkarnacija konference se že drugič odvija pod okriljem SIGCHI poglavja ACM Chapter Bled, ki je nastalo tudi kot posledica prejšnjih konferenc. O rasti HCI skupnosti v regiji pa priča tudi vse večje število prispevkov, ki prihajajo z vseh večjih visokošolskih zavodov v Sloveniji.

Teme, ki jih konferenca pokriva segajo od bolj uveljavljenih, kot so vizualizacija, snovanje grafičnih in uporabniških vmesnikov, ki temeljijo na govoru, personalizacija in prilagajanje interakcije uporabnikom, pa do virtualne in nadgrajene resničnosti ter uporabniških vmesnikih v turizmu, umetnosti in e-učenju.

FOREWORD

Human-computer interaction in information society is a conference organized by the Slovenian HCI community. The purpose of the conference is to gather researchers, practitioners and students in the field and offer the opportunity to exchange experiences and research results, as well as to establish contacts for future cooperations.

This year's fifth reincarnation of the conference is, for the second time, organized by the SIGCHI Chapter ACM Chapter Bled, which has been established also as a result of previous conferences. The growth of the HCI community in the region is witnessed by the doubled number of contributions coming from all major higher education institutions in Slovenia.

The topics covered by the conference range from the more established ones, such as visualization and design of graphical and audio user interfaces, personalisation and interaction adaptation, to virtual and augmented reality, and the ap plication of user interfaces in tourism, arts, and e-learning.

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The Fundamentals of Sound Field Reproduction Using a Higher Order Ambisonics System

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ABSTRACT

Conventional sound recording methods are based on recording the sound pressure level with a microphone which is after some signal processing reproduced by loudspeakers. In spatial audio, more than one microphone and loudspeaker are required to provide the sound source location information to the listener. Several spatial audio formats have been developed and some have successfully entered our homes, such as the the multichannel 5.1 surround system. Among spatial audio formats, Ambisonics stands out due to its capability of capturing and reproducing the whole sound field and is not limited to predefined loudspeaker setups. In the paper, the InnoRenew CoE's Ambisonics system is introduced and some of its underlying principles are explained. Furthermore, practical examples of the use of Ambisonics, also in relation to Virtual reality applications, are presented.

KEYWORDS

higher order Ambisonics, sound field reproduction

1 INTRODUCTION

Michael Gerzon [1] invented Ambisonics in the 1970s, and since it has mainly been a research topic in acoustics. It's higher order version was developed twenty years later but only recently it has become a commercially available recording system [2]. Currently, more and more user applications of Ambisonics are emerging since Ambisonicsis is being positioned as the audio framework of choice for virtual reality [3, 4].

The acoustic laboratory of InnoRenew CoE has currently been equipped with a higher order Ambisonics system. The system is composed of a 32 channel microphone [2], a set of 64 full range loudspeakers, a dedicated low frequency loudspeaker, all the required AD/DA converters and accessories, such as stands and cables. The equipment in shown on Figure 1.

The system will be used for perceptual acoustic experiments, mainly by exposing test subjects to different acoustic conditions and investigating their response. In fact, room acoustic conditions are essential for a healthy and creative working environment – one of the important research topics at InnoRenew CoE. Another use of Ambisonics is in combination with virtual reality systems (e.g. [7]) that can provide a multi-sensoric immersion experience to users.

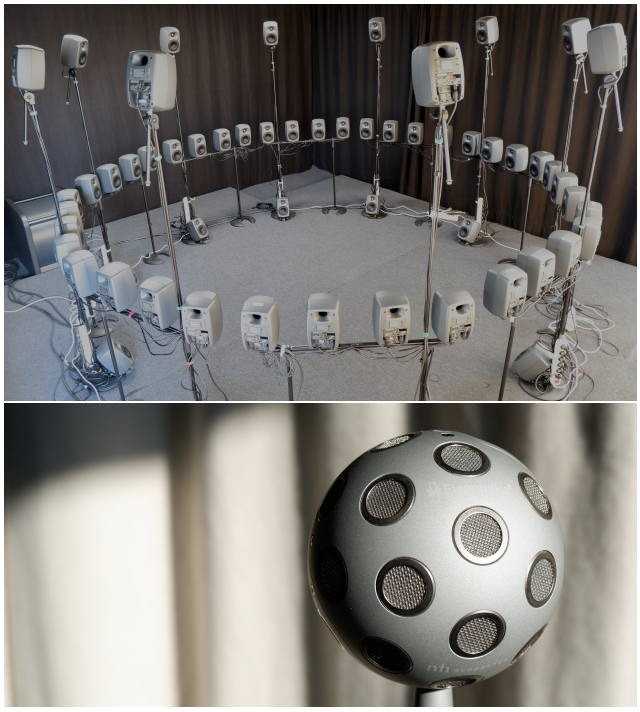

Figure 1: The higher order Ambisonics reproduction system with 64 loudspeakers (top) and the Ambisonics microphone [2] (bottom) which are part of the InnoRenew CoE's acoustic laboratory equipment.

2 RECORDING AND ENCODING

Ambisonics is a method of recording and reproducing a sound field and preserving its directional properties. The signal is coded, which is different in comparison with traditional multichannel audio formats (e.g., stereo, and 5.1 surround). In those, each channel contains the signal corresponding to a loudspeaker while in Ambisonics each channel contains derivatives of the pressure field. The encoded signals are known as B format.

In Ambisonics we record with several microphones spherically arranged on a (virtual) sphere. Summing properly weighted signals from each microphone is equivalent to recording with a microphone of a certain directional characteristic. Such processing is the basis of Ambisonics encoding [2], in which case the chosen directional patterns correspond to spherical harmonic functions (see figure 2).

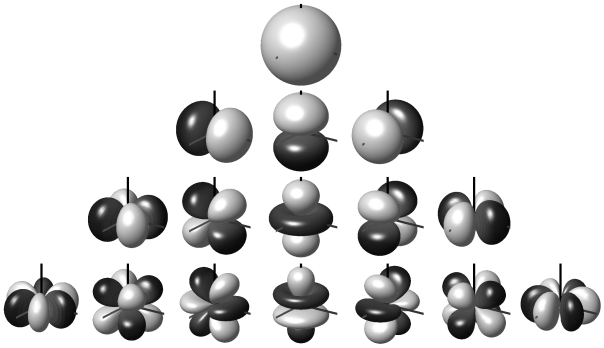

Figure 2: Polar patterns of spherical harmonics $Y_n^m(\theta, \varphi)$ of zero, first, second, third and fourth order (from top to bottom) (figure from [5]).

Spherical harmonic functions are grouped by their order number n and particular coefficient $m = -n, ...n$. Mathematically, each spherical harmonic corresponds to the angular portion of the solution of the wave equation. This way it is possible to capture the whole sound filed as it can be, in fact, decomposed into spherical harmonic functions

$$p(k, \mathbf{r}, \theta, \varphi) = \sum_{n=0}^{\infty} \sum_{m=-n}^{n} 4\pi i^n j_n(kr) A_{n,m} Y_n^m(\theta, \varphi) \qquad (1)$$

where φ and θ are the azimuth and elevation, $\mathbf{r}$ is the spatial coordinate and k is the wavenumber.

The general idea of a higher order Ambisonics encoding is to record sound with directionality patterns that correspond to polar patterns of spherical harmonics. As such, it is possible to encode the sound field in form of spherical harmonic decomposition factors instead of the sound pressure level at each microphone position.

The maximum order N at which we perform the expansion defines the order of the Ambisonic system. Each order contains $2N + 1$ channels, meaning that in total the ambisonics system of order N has $(N + 1)^2$ channels that have to be stored. Increasing the order to which the decomposition is done improves the directionality of the recording.

An important limiting factor for increasing the Ambisonic order is the number of microphones positioned on the sphere: the pressure is discretely sampled, which leads to artifacts, such as aliasing. Issues related to low frequency noise and several other technical limitations have been studied [3]. Generally, increasing the number of microphones is favored, although this obviously increases the cost of the system.

It is important to understand that the B format encoded signals can be as well manipulated with proper signal processing. For example, the sound field can be easily rotated for a certain angle, and it is also possible to focus to a certain direction of the sound field [6].

3 REPRODUCING THE SOUND FILED

The biggest advantage of Ambisonics over conventional multichannel spatial audio techniques (e.g. stereo, 5.1 and 7.1 surround) that consider fixed loudspeakers position is independence on the loudspeaker setup. In Ambisonics, the decoding from the B format takes into account the actual position of the available loudspeakers, which can be arbitrary chosen. Nevertheless, a high number of loudspeakers spatially distributed around the listener are required to provide a full and precise spatial impression.

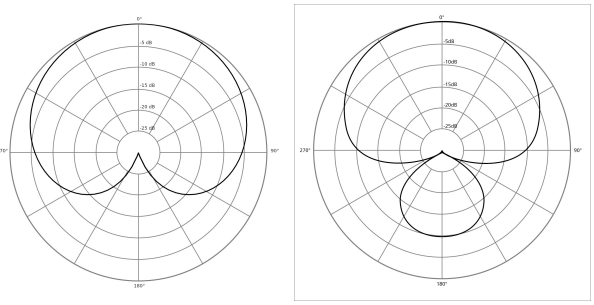

Figure 3: Example of a cardioid (left) and supercardioid (right) microphone polar pattern (figure from [8]).

The number of loudspeakers required is as well dependent on the order of the system. The $N-$th order requires a minimum $(N+1)^2$ loudspeakers, meaning that 9 loudspeakers are required for the 2nd order, 16 for the 3rd and 25 for the 4th.

There are several strategies for decoding the B format to be reproduced on a setup of loudspeakers. The basic idea is to directionally filter the recorded signals by virtual microphones pointing in the direction of each loudspeaker.

Setting the proper directionality patterns (see Fig 3) is the important part of the decoding process. In a regular layout, the signal emitted by a loudspeaker is the same as it would be recorded by a supercardioid microphone pointing towards that direction [6]. This means almost all loudspeakers emit sound at the same time, and for a given sound source position, loudspeakers in the opposite direction emit in opposite phase.

4 THE AMBISONICS SYSTEM IN USE

Ambisonics systems are an useful research tool in acoustics, mainly because they enable to reproduce sound emitted by sources together with the acoustic environment in which they are located. An important example of such use are the investigations carried out by Tapio Lokki [9] with his group who have been investigating perceptually relevant acoustic properties of concert halls. In their research, listeners have been asked about their preferences about the acoustics of different concert halls in which the same orchestra was performing. As an individual's acoustic memory is strongly affected by the time that has passed since each concert experience, it is required for such research to migrate the listener and orchestra between concert halls immediately. This can be achieved by an Ambisonics system in which recordings can be switched by a push of a button.

Figure 4: Photo of a listener in the Ambisonics loudspeakers ring at the InnoRenew CoE's Acoustic lab. The control over the system and perceptual response is based on a tablet PC as an interface.

Currently at InnoRenew CoE, we are setting up the Ambisonics system for the listener to rate different acoustic environments. The research is not limited to a specific environment type, such as concert halls, but includes acoustic environments to which we are exposed on a daily basis (commonly referred to as soundscape [12]). The recording will be performed on several different locations that include noisy and pleasant environments, such as high-traffic roads, busy workspaces and nature.

The interaction of the user with the system can be designed in various ways. Firstly, we are relying on a tablet PC as shown in Fig. 4. Using the tablet, the playback is controlled and the response from individuals is gathered. The system can be upgraded with more advanced response tracking options, such as performing eye-tracking or tracking the electrodermal activity of the test subject.

Spatial sound can be incorporated into virtual reality (VR) interfaces, such as VR headsets. The most accessible approach is to use headphones for which the signals have to be processed based on Head-related transfer functions [10]. The main drawback in this case is that wearing headphones is not natural to users and can produce discomfort. It is well known [11] that the listener does not localize the sound source as being external, but rather positions it in between the ears. This phenomenon of using headphones is known as lateralization of sound sources [11].

Generally, the relative position/orientation of the sound source in relation to the listener's ears changes over time, meaning that Head-related transfer functions applied to process the audio content have to adopt accordingly. Therefore, when using headphones in VR head tracking and real time audio processing are required.

In this perspective, the use of Ambisonics advantageous as the full sound field is reproduced and the listener can freely rotate his head while localization clues are correctly perceived. Additionally, in Ambisonics the ears are free from wearable equipment, which is a more natural condition for the user.

A relevant use of Ambisonics in relation to VR is also recording the sound field using an Ambisonics microphone and reproducing it over headphones instead of an Ambisonics reproduction system composed of a high number of loudspeakers. In fact, the B format encoded signals can be processed for a binaural playback for any arbitrarily chosen head rotation. Recently, many commercial second order Ambisonics microphones containing four microphones have become available on the market together with dedicated digital audio work station plug-ins for binaural decoding.

5 ACKNOWLEDGMENTS

The author gratefully acknowledges the European Commission for funding the InnoRenew project (Grant Agreement #739574) under the Horizon2020 Widespread-Teaming program and the Republic of Slovenia (Investment funding from the Republic of Slovenia and the European Union's European Regional Development Funds).

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