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Head-Related Transfer Functions: Localizable Audio for Virtual Reality

Evan Bubniak, Daniel Pak, Miho Takeuchi

ADVISED BY PROFESSOR MARTIN LAWLESS

Correctly locating sounds is crucial when creating an immersive audio environment for virtual reality. Synthesizing sounds for headphone playback requires transforming them through filters called head-related transfer functions (HRTFs), containing information about the sound's location and the user's anthropometric features. Obtaining an HRTF profile, consisting of HRTFs measured at hundreds of locations arranged spherically around the listener, requires an extensive experimental setup. The goal of this project is to extrapolate an HRTF profile from a sparse amount of HRTF measurements. An artificial neural network, trained on the HUTUBS database containing HRTFs measured at 440 locations for 93 subjects, accepts a small number of HRTFs measured from predetermined locations, selected through grid search optimization, to predict the full profile. Based on these locations, an experimental setup, consisting of full-range speakers on custom-made speaker stands and in-ear binaural microphones, was constructed to collect a few HRTFs from participants. The participants' HRTF profile is then extrapolated for audio localization in virtual reality.

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NINS: Non-Invasive Intranasal Neuromodulation System

Jared Lam, Jacques Mosseri, Hyomin Seo,
Ruben Solano, Brian DeHority

ADVISED BY PROFESSORS ERIC LIMA, CARL SABLE, AND ALEXIS BRUHAT (MOUNT SINAI)

Acute ischemic stroke (AIS) is a devastating disease that permanently affects millions of people each year. The typical treatments for AIS are mechanical thrombectomy and intravenous tissue plasminogen activator (IVtPA), but the window of efficacy for such treatments is very short. Given how rapidly AIS affects brain tissue, most patients are left with no viable treatment option. Stimulation of a facial nerve behind the nose, called the sphenopalatine ganglion (SPG), is proven to increase collateral blood flow in the brain. We are prototyping a novel, non-invasive medical device to stimulate the SPG as a strategy to extend the window of efficacy for AIS treatments. We are building and testing a proof-of-concept model inserting a catheter through the nasal cavity, locking it into place via inflatable balloons, and electrically stimulating the SPG with an electrode.

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VOOV Shoes: A Step Towards Sustainability

Enea Dushaj, Chris Mignano, Yuval Philipson

ADVISED BY PROFESSORS ERIC LIMA AND DIRK LUCHTENBURG

The production of a single pair of running shoes is estimated to release 30 pounds of carbon into the environment. With 23 billion pairs of shoes made and sold globally each year, and 300 million pairs of shoes thrown away in the US alone, the shoe industry is responsible for 2% of all carbon emissions. Climate change is the largest issue facing humanity today, and to meet global climate targets, the shoe industry desperately needs an inexpensive, sustainable solution.

VOOV footwear strives to create the world's most sustainable shoes, employing a unique attachment mechanism that allows users to swap uppers and soles at will. Our patent-pending technology stands to reduce global carbon emissions from footwear products by up to 33%. By changing the way they interact with their shoes, VOOVers can save money and express their individuality, all while preserving the planet.

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Stopping the Spread: HVAC Controls for Mitigating COVID-19

Amal Bukhari, Louis Lane, Lutor Mei, Jaywon Woo

ADVISED BY PROFESSORS MELODY BAGLIONE, PHILIP YECKO, AND SCOTT N. BONDI

As members of the Cooper community, making 41 Cooper Square safer in response to the pandemic is of primary importance to us. Measures of increasing safety such as enforcing mask wearing, social distancing and regular testing have already been implemented by the Cooper Union. Our project focuses on using building controls to improve indoor air quality as an extra precaution against COVID-19 spreading via respiratory aerosols at 41 Cooper Square.

The building control methods this project focuses on are increased outdoor air ventilation, air filtration and relative humidity control. Reference materials for the Cooper Union facilities team to use in identifying and implementing these changes via adjustments to the 41 Cooper Square HVAC system will be produced. Experimental methods and computational fluid dynamics will be employed to illustrate how significant these adjustments are in improving indoor air quality.

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Lightweight Mars Ascent Vehicle Design

Alex Seligson, Harris Paspuleti, Andrew Huh, Hannah Quirk

ADVISED BY PROFESSOR SVEN HAVERKAMP

NASA's goal is to have humans walk on Mars by 2035. A Mars Ascent Vehicle (MAV) is needed to safely transport astronauts from the surface of Mars to a low mars orbit where they meet up with their return vehicle. Previous MAV designs are too heavy and costly to be feasible. The Cooper Union Mars Ascent Vehicle is a cost efficient and light weight solution designed to meet NASA requirements. Weight savings were achieved by reducing the crew size from four astronauts to two. This MAV utilizes a unique hybrid in-situ propulsion system that greatly reduces mass by eliminating the need for complex cryogenic cooling systems by using paraffin fuel and producing oxidizer on the Martian surface. The final design is a two-stage vehicle with a 3588 kg dry mass. The proposed MAV will travel directly to a higher altitude rendezvous orbit, therefore limiting the risk involved in multiple docking events and eliminating the need for an expensive taxi vehicle.

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Computer Vision-Based Robotic Arm

Zhiyang Chen, I-An Huang, Zhihao Wang, Di Mei

ADVISED BY PROFESSORS DIRK LUCHTENBURG AND CARL SABLE

Robotic arm-based human-robot interaction is an upcoming trend given the drastic improvements in computer vision and artificial intelligence. Robotic arms have been favored by the manufacturing industry for decades because of their flexibility in performing a variety of tasks. Despite their importance, educational robotic arm technologies are not easily accessible mainly due to their exorbitant cost. We are making educational robotic arms more accessible by developing inexpensive robotic arm hardware and an open-source educational platform. With our platform, robotic hobbyists will be able to learn how to manipulate robotic arms to perform tasks and experiment with deep learning-based object detection.

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Visibly Stressed: Digital Image Correlation as an Educational Tool for Material Deformation Study

Rose Gebhardt, Chaerin Jun

ADVISED BY PROFESSOR WOOTTON AND DOUG THORNHILL

Digital image correlation (DIC) is a useful strain/stress measurement tool, but it can be inaccessible for numerous reasons: setting up the software from a repository can be difficult for inexperienced users; relaying data from the sensor to the program may be hard; the source code may require a software with an expensive license. Our project aims to tackle these issues by making source code more accessible and create a simple hardware setup for beginner users. Our system uses a phone camera to feed data to an open-source DIC software. Our goal is to determine factors that reduce accessibility and address them. We tested lower-cost hardware to determine if it could perform as well as the high-speed high-quality cameras typically used for DIC, and we developed a graphical user interface (GUI) to make the software more friendly for those new to programming. The program can serve as an educational tool for material deformation studies at Cooper Union.

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Housing of the Future: The Solar Decathlon

Adam Blank, Alex Yezril

ADVISED BY PROFESSORS MELODY BAGLIONE AND DAVID WOOTTON

One of the largest energy consumers are buildings, not only in continued use and maintenance, but also in construction. The U.S. Dept. of Energy Solar Decathlon is a collegiate competition that challenges students to design energy efficient buildings that meet "Net Zero Energy Ready" and federal and state standards and requirements. The Cooper Union Solar Decathlon team designed the Solar Hinge, a multifamily affordable housing building with a health clinic for families at risk of homelessness for the Vital Brooklyn initiative. The project utilizes solar panels, heat pumps and an Underfloor Air Distribution (UFAD) ventilation system to integrate mechanical systems into pre-fabricated modules. The inaugural Cooper Union Solar Decathlon team competed as a Finalist Team before a panel of industry jurors in the 2021 Design Challenge.

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