PROJECT DESCRIPTIONS
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INTELLIGENT DESALINATION FOR 21ST CENTURY AGRICULTURE

WHO

Department
MIT Mechanical Engineering
Principle Investigator
Professor John H. Lienhard V
Lab Liaison
Kishor G. Nayar

A bench-scale monovalent selective electrodialysis (MSED) stack that selectively removes monovalent ions from a water stream. The stack is a part of a prototype of a desalination technology called, Intelligent Selective Electrodialysis (ISED), being developed by Mechanical Engineering PhD Candidate, Kishor Nayar, and his advisor Prof. John H. Lienhard V. ISED is being developed to tailor irrigation water for agricultural applications.

DESCRIPTION

Globally, salinity in irrigation waters costs farmers $30 billion in revenue losses. With increasing populations, the problem of salinity in irrigation waters is increasingly threatening global food security. To reduce salinity in irrigation waters, sophisticated farmers, such as hydroponic crop growers, currently use reverse osmosis (RO). However, RO removes all ions in the water including divalent ions such as Ca2+ and Mg2+ that are beneficial for crops, leading to the need for fertilizer additions and expenses. Improper combination of RO and fertilization can lead to sub-optimal crop yields for many growers. The Lienhard lab is developing a technology that could improve agricultural practices and crop yield and become the new standard desalination technology for use in agriculture. The system is called Intelligent Selective Electrodialysis (ISED)
and can be used to reduce water salinity intelligently. ISED is a development over an existing technology used to treat high salinity seawater called Monovalent Selective Electrodialysis (MSED). ISED uses selective membranes to tailor the ion content of irrigation waters to meet crop nutrient requirements and increase yields. Compared to the use of the existing RO process, ISED is expected to improve crop yield while using less water and fertilizer use. The immediately addressable market of the technology consisting of: hydroponic farming in Mexico, Israel, Europe and USA, and orchard farming in California, is $1.5 billion. At this scale, ISED is expected to help food production for millions of people. The cost of ISED is expected to decrease over the next 7 years to serve lower revenue markets such as in the developing world and in conventional farming which will further increase the deployment. ISED will make water treatment for agriculture more sustainable and help ensure water and food security.

The ISED concept has raised $75,000 in grant funding for commercialization from the J-WAFS Solutions Program and was a finalist at the 2017 MIT Water Innovation Prize, the 2017 MIT Clean Energy Prize and the 2017 MIT Food and Ag. Prize. Currently, the team is carrying out primary market research to validate the appeal of the ISED concept over RO and ensure product-market fit. Funds have been arranged for travelling to parts of the US and Mexico for end-user interviews.

MORE

News article on project currently funding MSED work:

News article on prior electrodialysis research from Lienhard Group

Paper on diverse applications of Electrodialysis:
https://dspace.mit.edu/handle/1721.1/102495

Paper on use of Electrodialysis at high salinity:
https://dspace.mit.edu/openaccess-disseminate/1721.1/105367
NOVEL POLYMER FOR
SELECTIVE HEAVY METAL REMOVAL FROM WATER

WHO

Department
MIT Chemistry
Principle Investigator
Professor Timothy M. Swager
Lab Liaison
Wen Jie Ong

DESCRIPTION

The water treatment industry lacks innovation in fundamental chemistry development. The prevailing solutions across a range of industries rely on either century-old precipitant technology, or expensive membrane and energy-intensive distillation technology. These solutions tend to be cumbersome, costly and/or incompletely effective at removing problematic contaminants, such as mercury, selenium, and arsenic. We are poised to enable next-generation water treatment with minimal energy input using new chemistry developed at MIT. Our core technology is a polymeric media that selectively and effectively removes toxic contaminants from water by adsorption. Our first polymer technology focuses on selective and effective removal of toxic heavy metals such as mercury, lead and cadmium. The advantages of this polymer technology include: 1) 99.8% heavy metal removal efficiency, 2) longer durability and lower cost due to the high selectivity of the polymer for toxic heavy metals over other harmless cations, and 3) no energy input requirement. Our novel polymer technology can be applied to a wide range of applications, ranging from wastewater treatment in coal power, mining and oil & gas to potable water production.
THERMOPHOTOVOLTAIC POWER GENERATION

WHO

Department
Principle Investigator
Lab Liaison

MIT Institute for Soldier Nanotechnologies
Marin Soljacic, Ivan Celanovic
Vernonika Stelmakh, Walker Chan

DESCRIPTION

Our technology converts fuel to electricity using light as an intermediary. Specially, it works by burning fuel in a microcombustor to heat a photonic crystal thermal emitter to incandescence, leading to infrared radiation which drives specialized photovoltaic cells to generate electricity. Simply put, we can deliver watts of electricity at the fuel flow of a lighter, in a volume a fraction of a cubic inch.

We have overcome the technical challenges that were limiting thermophotovoltaics until now by developing new processes, using new materials, improving thermal stability, and improving system integration. Indeed, we have demonstrated unprecedented heat-to-electricity efficiencies exceeding 4%, greater than the 2–3% efficiencies that were previously thought to be the practical limit, and we predict that over 12% efficiency is achievable with only engineering optimization. For reference, a 1.5% efficiency corresponds to the energy density of lithium ion batteries.
Our work opens new opportunities to free portable electronics, robots, and small drones from the constraints of bulky power sources. Thus we believe it would have a number of applications in the defense and commercial sectors, including emergency response, mountaineering and outdoor expeditions, remote sensing, ocean buoys, deep space probes (with radioisotope heat source), drone flight sustainment, and energy access in emerging markets.

MORE

Our most recent publication is a great resource to learn more about this technology:

http://pubs.rsc.org/en/content/articlelanding/2017/ee/c7ee00366h#!divAbstract
FlockTracker

WHO

Department
Principle Investigator

MIT Department of Urban Studies and Planning
Professor Christopher Zegras
DESCRIPTION

Flocktracker is a content-agnostic platform that aims to democratize field data collection. We provide an easy-to-deploy, easy-to-manage, ad-hoc, cloud-based field data gathering method, leveraging smartphone technology and designed to generate valuable insights in a low cost, and low hassle way. The platform is designed to replace traditional approaches to collecting field data to enable easy and rapid set-up and deployment of a range of data collection projects, adding high resolution attributes to the data collected (e.g., time and place stamps) and eliminating much of the collection, coding and storage hassle. The technology enables a range of users, from citizens to academics to businesses, to set up projects, collect a broad mix of field data types, store and manage the data in the cloud, monitor data-collection in real-time, and, ultimately, choose to share their project results among a wide range of interested parties.

The Flocktracker platform enables innovative research approaches both in the quantitative and the qualitative realms. We suspect that the current lack of accessible and easy-to-use, mobile- and cloud-based tools leaves many great project ideas unrealized. We envision an empowered community co-creating data collection projects, collaboratively collecting and exploring data to better understand their environment and making an impact on the decisions about the future of their communities. Our most current pressing challenge is to better understand Flocktracker’s potential market segments and their needs, how to best respond to them, and what business model will best allow Flocktracker to fulfill its technological and societal potential.

MORE

Website  
http://flocktracker.org/
LIGHT FIELD PHOTOGRAPHY FOR COMPUTER VISION

WHO

Department  Brown University Department of Computer Science
Principle Investigator  Professor Stefanie Tellex
Lab Liaison  John Oberlin

DESCRIPTION

Most robots cannot pick up most objects most of the time. However, because it can move its camera, a robot can obtain new views of the object, increasing robustness and avoiding difficulties in any single view. To benefit from this technique, the robot must integrate information across multiple observations. One approach is to use feature-based methods on individual images, as in the winning team for the Amazon Picking Challenge, but this approach does not incorporate information about the viewing angle and can still struggle with non-Lambertian objects. Other approaches create 3D meshes from multiple views but do not work well non-Lambertian objects, which are still considered an open problem.

We have created a new framework for perception that uses a robot’s ability to move its camera (or a stationary camera array) to create a light field image. Light fields have been used in graphics and virtual reality for 3D rendering. Our approach is to instead use wide-aperture light field (either by moving a camera or a very large camera array) to perform perception tasks. Using this technology, we can localize objects with a monocular camera to within 2mm,
pick robustly (hundreds of times in a row), extract 3d structure, and remove glare artifacts. We have explored using this technology for manipulation on mobile robots, and also for flying robots such as quad-rotor helicopters. Additionally we suspect we could create a device in a form-factor somewhat like the Kinect or Kinect 2 which contains a camera array (or an array of moving cameras) and extracts 3d structure for applications such as autonomous driving, surveillance, video games (like the Kinect.) The biggest technical challenge at the moment is to make it run faster and determine optimal movement patterns for the camera. The biggest project challenge is to identify the most promising opportunities and figure out the next steps forward. Societal implications include better robots with improved perception, which can have profound impacts from autonomous driving to household assistance robots. Additionally improved perception can aid in infrastructure inspection, surveillance, safety and decision making.

MORE

Youtube video
https://youtu.be/rJAti2ymAnY

Conference Paper

AI Award-Winning Paper
NOVEL HYDROGEL SCAFFOLDS AND DEVICES

WHO

Department
Principle Investigator

MIT Department of Mechanical Engineering
Professor Xuanhe Zhao

DESCRIPTION

Hydrogels are gels where the liquid used is just water. Typical hydrogels are weak and brittle though, limiting their scope of use. The Soft Active Materials laboratory has developed a durable hydrogel that even though it can contain 90% water it is tougher than cartilage. They have additionally developed methods for bonding the hydrogel to a variety of solids and even for 3D printing the hydrogel. It is also possible to tune the rigidity of the gel with different polymers depending on the application. Some initial applications the technology has been proposed for is wound healing, a smart glove or soft robotics.

MORE

Lab site
http://web.mit.edu/zhaox/www/

Popular Science article
Gizmodo article
http://gizmodo.com/these-crazy-living-gloves-glow-when-you-touch-certain-c-1792435739

MIT News article
http://news.mit.edu/2016/stretchy-optical-fibers-implanting-body-1017
TECHNOLOGIES FOR HARDWARE ROOT OF TRUST

WHO

Organization  Draper
Principle Investigator  Murali V. Chaparala

DESCRIPTION

Draper has developed CMOS compatible passive, unpowered thermal and radiation sensors capable of capturing attempts to image, de-solder, de-lid or image the IC; and perfected mechanical processes that make the silicon die fragile and prevent intact removal from its package. These technologies when employed with a full encryption engine and near-field technology to power and communicate enable an embeddable hardware root of trust solution that can authenticate the security and integrity of the host system.
STRUCTURED NUCLEIC ACID NANOPARTICLE THERAPEUTIC DELIVERY PLATFORM

WHO

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<td>Lab Liaison</td>
<td>Tyson Shepherd</td>
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DESCRIPTION

Targeted, efficient delivery of therapeutics including small molecules, messenger RNAs, and CRISPR/Cas9 gene editing enzymes is arguably the largest current bottleneck in the treatment of human diseases. Over three decades of research in both industry and academia have still not offered solutions to this problem, despite billions of dollars of funds expended on polymer-, liposomal-, viral-, and other nanotechnological approaches. As an alternative delivery modality, in this proposal we seek funding to translate structured DNA and RNA nanoparticles to the clinic. Key advantages of our approach include: 1) full synthetic control over the chemical and structural composition of the delivery vehicle; 2) in vitro production for homogeneous and reproducible composition; 3) arbitrary functionalization of internal therapeutic payloads and external targeting vectors for diverse therapeutic applications ranging from cancer to genetic, infectious, and auto-immune diseases; 4) nucleic acid composition ideal for conjugating therapeutic nucleic acid payloads, as well as leveraging CpG domains for immunological applications.