Bill Yen

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Research Interests

Broadly— Addressing the power and communication bottlenecks for IoT systems.
Lately— Designing low-cost wireless sensors; agricultural/ocean monitoring; sustainable materials for electronics; energy harvesting; satellite communication.

I am an **interdisciplinary maker** and **environmental scientist** passionate about solving issues related to food, water, and energy using smart technologies.

Education

2023- **PhD, Electrical Engineering, Stanford University**
Advisor: Zerina Kapetanovic
Stanford Graduate Fellow

2019-2023 **Bachelor of Science, Mechanical Engineering, Northwestern University**
Minor in Environmental Engineering | Certificate in Human-Centered Design
Concentration in Robotics and Controls | Accreditation in LEED AP BD+C
Cumulative GPA: 3.90/4.00

Major Awards, Honors, Highlights

Featured by The Independent, MIT Technology Review China, and Hackster.io
Highlighted by Northwestern Magazine and Institute for Sustainability as "Grad to Watch"

11/2024 **Prototypes for Humanity Winner**. *Awarded $20,000 by Her Highness Sheikha Latifa bint Mohammed bin Rashid Al Maktoum among 2700+ applicants from 100+ countries as the winner of the energy category in the 2024 Prototypes for Humanity exhibition in Dubai.*

07/2024 **Honorable Mention in Fast Company Innovation by Design**. *Selected for having one of the best designs of the year in both the Student and Sustainability categories with Terracell, a fuel cell that generates power from soil.*

06/2023 **Ovid W. Eshbach Award.** *Given to 1 outstanding senior in the McCormick School of Engineering who "most closely typifies the ideal engineering student" and displays overall excellence in scholarship and leadership.*

02/2023 **Wildcat Impact Award for Discovery.** *Recognized for founding AutoAquaponics over COVID-19 and for significantly contributing to improving the quality of student life at Northwestern.*

04/2021 **Grand Winner in U.S. DOE Solar Decathlon Design Challenge.** *Placed first out of 50+ international teams in the Residential Building division with the design of NUHome, a net-zero urban single-family home.*

08/2020 **5th in PDMA Global Innovation Challenge.** *Placed 5th among numerous undergraduate and graduate teams from all over the world in this international product design competition.*

Other Awards

11/2022 **Tau Beta Pi Inductee.** *Selected for outstanding academic performance in the senior class.*

09/2021 **The Energy & Environmental Building Alliance NextGen Scholar.** *One of seven students from all over the world selected to present at the 2021 EEBA High Performance Building conference in Denver, CO.*

08/2021 **1st Place Scholarship from Illinois Association of Environmental Professionals.** *Awarded for academic excellence and a winning essay on the business case for sustainability.*

09/2020 **McCormick Design-a-thon Finalist.** *Placed top 4 among 40+ undergraduate and graduate teams from Northwestern University with a functional iOS app prototype.*

04/2020 **1st in White Space Product Development Challenge.** *Won the product design competition hosted by the Segal Design Institute and the PDMA.*

04/2020 **Summer Undergraduate Research Grant Recipient.** *Received $3k to conduct an independent research project on the performance of soil microbial fuel cell under Prof. George Wells from Northwestern's Department of Civil and Environmental Engineering.*

03/2020 **1st Place in Launch Entrepreneurship Accelerator.** *Awarded $300 from The Garage at Northwestern for designing and pitching FishEats, an automatic fish feeder.*

12/2019 **Segal Design Award.** *Highlighted for building the best prototype for the user and client in Northwestern's Design Thinking and Communication course with a custom reverse walker.*

Publications

06/2024 **Towards Designing Self-Powered Biodegradable Sensors for Agricultural Applications**
Bill Yen, Zerina Kapetanovic
Proceedings of the 2nd Workshop on Advances in Environmental Sensing Systems for Smart Cities (EnvSys 2024)
Presented in MobiSys 2024

02/2024 **Long-Range Backscatter Connectivity via Spaceborne Synthetic Aperture Radar**
Geneva Ecola, ***Bill Yen***, Ana Banzer Morgado, Bodhi Priyantha, Ranveer Chandra, Zerina Kapetanovic
arXiv

01/2024 **Soil-Powered Computing: The Engineer's Guide to Practical Soil Microbial Fuel Cell Design**
Bill Yen, Laura Jaliff, Louis Gutierrez, Philothei Sahinidis, Sadie Bernstein, John Madden, Stephen Taylor, Colleen Josephson, Pat Pannuto, Weitao Shuai, George Wells, Nivedita Arora, Josiah Hester
Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies (PACM IMWUT), Vol. 7, No. 4
Presented in UbiComp 2024
Top 4 most downloaded paper in IMWUT history (7 yrs, 1464 papers, 1.2M downloads)

Posters

04/2024 **Towards Carrier-Free Near-Field Communication via Modulated Johnson Noise**
Bill Yen, Zerina Kapetanovic
21st USENIX Symposium on Networked Systems Design and Implementation (NSDI)

06/2022 **Harnessing Power from the Soil**
Weitao Shuai, ***Bill Yen***, Laura Jaliff, Abu Bakar, Jason Huang, Alex Curtiss, Colleen Josephson, Josiah Hester, Pat Pannuto, George Wells
2022 Association of Environmental Engineering and Science Professors Research and Education Conference

Research Experiences

2023- **Stanford Smart Sensing Systems Lab.** *Graduate Researcher*, Stanford CA

- Developing ultra-low power and low-cost wireless sensors for deep-sea sensing at the Stanford Smart Sensing Systems (S4) Lab with Prof. Zerina Kapetanovic.
- Built a passive nearfield communication system with modulated Johnson noise using USRP software-defined radios, low-noise amplifiers, and digital signal processing techniques.
- Designed custom retroreflectors for modulated ground-to-satellite communication using Ansys HFSS.

2020-2023 **Ka Moamoa Lab.** *Research Assistant,* Evanston IL

- Designed resilient microbe-powered soil batteries to provide renewable energy supplies to distributed sensor networks using 3D printing and other rapid prototyping technologies.
- Prototyped a low-power sensing platform to transmit moisture data wirelessly with < 1 μW of power.
- Optimized a custom backscatter communication system by leveraging HackRF and GNU Radio.
- Published a first-author journal paper on building practical soil microbial fuel cells for wireless sensor nodes, which became one of the top 8 most downloaded papers in the journal's history within a year.

2020-2023 **Wells Environmental Biotechnology Lab.** *Research Assistant*, Evanston IL

- Built the QIIME Output Cleaner, an intuitive Python software with an integrated graphical user interface to convert 16s rRNA bioinformatics data into community composition plots for visualization purposes.
- Conducted extensive literature reviews to benchmark existing microbial fuel cell designs and identify potential microbes that can generate electricity by breaking down organic carbon.
- Second author to a poster presentation for the 2022 AEESP conference on terrestrial microbial fuel cell.

Industry Experiences

06/2022-08/2022 **CNH Industrial.** *Crop Production Innovation Intern*, Burr Ridge IL

- Designed and prototyped a mobile, multi-depth soil moisture and temperature sensor module, resulting in 3 separate IP filings.
- Manufactured agriculture-grade ruggedized waterproof housings for sensitive electronics using sheet metal, stereolithography, and selective laser sintering.
- Built custom printed circuit boards to measure soil temperature and moisture levels in real time and transmit the data to users via CAN bus.

06/2021-09/2021 **General Motors.** *Environmental Engineering Intern*, Bedford IN

- Automated chemical inventory workflow across GM plants globally by building a custom Python data processing application with a complete GUI and creating the necessary training material for GM's engineers.
- Proposed and facilitated the acquisition of two novel bio-electrochemical sensors for real-time BOD measurements to create an outfall diversion system for Bedford GPS's industrial wastewater treatment plant.
- Constructed 12+ standardized procedures for the operation and maintenance of a new Dissolved Air Flotation mixed liquor suspended solid removal system and a turbidity sensor module to aid in their installation.

Project Experiences

09/2024 - Present **Smartphone Sensors.** *Engineer*, Stanford CA

- Developed a linear Kalman filter in Python to convert readings from an ICM-20948 accelerometer and gyroscope into spatial positions.
- Built a pseudorandom bit sequence generator to drive a 5 x 7 touch screen and a signal processing pipeline to extract touch states using circular autocorrelation.
- Prototyped a photoplethysmography sensor using LEDs, ambient light sensors, and a Raspberry Pi.

03/2024 – 06/2024 **Analog Function Generator.** *Engineer*, Stanford CA

- Designed an analog function generator capable of outputting square, sine, and triangle waves from 2 Hz up to 2 MHz with less than 3% total harmonic distortion across the entire bandwidth.
- Built differential amplifiers, Schmitt triggers, switched current sources, buffers, and sine shapers using analog discrete components.
- Hand constructed the device using copper tape layouts on an FR4 board.

01/2024 – 03/2024 **FM Radio Receiver.** *RF Engineer*, Stanford CA

- Designed and constructed a functional FM radio receiver using bare transistors, inductors, resistors, and capacitors on an FR4 board.
- Leveraged LTspice to simulate the narrowband/broadband amplifier, oscillator, RF mixer, IF filter, and FM demodulator modules of the system.
- Verified performance metrics using spectrum analyzers, vector network analyzers, and time domain reflectometers.

09/2019-06/2023 **Engineers for a Sustainable World.** *Co-President*, Evanston IL

- Led a multidisciplinary team of 20+ engineers in the design and construction of AutoAquaponics, an automated farming system that can be monitored and controlled remotely with sensors, actuators, ESP32s, and a Raspberry Pi.
- Developed an IoT network of microcontrollers with built-in data acquisition and BLE messaging capabilities using Python and C++ to enable the system's remote monitoring and feedback loop controlling process.
- Built the power electronics and sensing portion of the hardware platform prototype, which can be accessed remotely through a React site connected to Google Firebase.
- Organized regular system tours for middle and high schoolers of marginalized identities to educate them on sustainable urban agriculture in partnership with the Society of Women Engineers and National Society of Black Engineers.

01/2023-03/2023 **Series Elastic Backdrivable Robot Joint.** *Controls Engineer*, Evanston IL

- Built a teleoperated robotic joint featuring a series elastic actuator with backdrivability to enable safer human- robot interaction and more dexterous robots capable of handling delicate materials.
- Designed an admittance control system that allows the robotic joint to follow the external force applied to its linkages while traveling to desired positions to avoid injuring nearby human.

09/2022-12/2022 **Swarms and Multi-Robot Systems.** *Engineer*, Evanston IL

- Built decentralized controllers for simulated robotic swarms to facilitate complex behaviors like localizing agents without the use of environmental sensors, separating out groups of robots without direct communication, and creating a robust flock of 20+ differential drive robots with accurate heading alignment.
- Implemented the tasks described above with Python using algorithms from existing publications.
- Tested the flocking controller on physical robots under the guidance of Prof. Michael Rubenstein.

03/2022-06/2022 **McCormick Autonomous Robot Design Competition.** *Team Lead,* Evanston IL

- Devised the hardware, electronics, and software system for a fully autonomous differential drive robot capable of traveling through a maze and dropping small objects in various parts of the environment.
- Facilitated precise motions of the robot with a closed-loop PID controller implemented in C++.
- Manufactured the robot chassis and wheels using 3D printing and laser cutting.

07/2020-04/2021 **U.S. DOE Solar Decathlon Design Challenge.** *Water Systems Engineer*, Evanston IL

- Engineered a centralized, efficient, and prefabrication-friendly residential water system for an affordable Zero Energy Ready Home based on a site in Chicago, IL.
- Reduced the home's overall potable water consumption by 60.5% relative to LEED, ENERGY STAR, and WaterSense baselines by utilizing low-flow fixtures, graywater reuse, and smart landscaping strategies.
- Presented the design at the 2021 EEBA High Performance Building conference.

12/2019-04/2020 **Arbor Air Purifier.** *Team Leader*, Evanston IL

- Invented Arbor, a self-cleaning air purifier that uses live moss, activated carbon, and an UV-C bulb to remove airborne contaminants, increase humidity, and release negative ions.
- Led a team of 3 through the conceptualization, prototyping, and presentation phases of the White Space Product Development and PDMA Global Innovation Challenge.
- Filed for a provisional utility patent on the use of live moss for airborne contaminant removal.

Skills

Software	C, C++, Python, Git, Linux, MATLAB, HTML, CSS
Electronics	PCB Design (KiCAD, EAGLE, EasyEDA), Software-Defined Radio (USRP, HackRF, GNU Radio), Wireless Communication (RF Backscatter, BLE, LoRa, WiFi), Circuit Modeling (LTspice, HSPICE, Cadence Virtuoso), Mechatronics, Embedded Programming (ESP32, PIC32, Arduino, Raspberry Pi), Analog Circuit Design, Digital Feedback Systems, Digital Communication Protocols (SPI, I2C, CAN, RS232)
Mechanical	3D Printing (FDM, SLA, SLS), Machining (Mill/Lathe, Laser Cutter, Water Jet), GD&T
CAD	SOLIDWORKS, NX, AutoCAD, Creo, Onshape, Keyshot Studio
Languages	Mandarin (Native), Taiwanese (Native), Spanish (Proficient)
Others	Patent/White Space Analysis, Literature Review, Scientific Writing, Design Sketching, Hazardous Material Training, Bioinformatics, Organic Chemistry