

2013

Intel ISEF  
Special Award Winners



# INTEL ISEF

## CERN Special Award Winners 2013



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Last: **Aitken**

First: **Colin**

Country: USA

Age: 17

**Project:** Dots and Lines: A Combinatorial Interpretation of the Homotopy Groups of Finite Topologies

The homotopy groups of a topological space are commonly studied as a topological invariant that gives information about the space's holes, homotopy type, and connectedness. An attempt to construct an analogue of homotopy groups for graphs was examined by Atkin and Smith, but the groups they associate to a graph  $G$  do not in general correspond to the homotopy groups of a finite topology whose associated graph is  $G$  when such a topology exists.

My project presents a new definition of the homotopy groups of a graph  $G$ , in the spirit of Atkin by using only combinatorial methods, and shows that under this new definition the homotopy groups of  $G$  are indeed the same as any topology whose associated graph is  $G$ . In doing so, this demonstrates that a 1966 construction of Stong is sufficient to construct all paths in a finite topology, which was previously unproven.

This new definition allows for the construction of a (possibly infinitely-generated) recursive presentation for an arbitrary homotopy group of a finite topology, graph, and/or simplicial complex. In addition, it provides a test for graph isomorphism which "usually" can tell when two graphs are not isomorphic in  $O(v^3)$  time.

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## Motivation

When I was in younger, I used to sneak into my dad's office to read books.

Early on, these were things like comic books and books of jokes, but as I grew older I wanted to read bigger and bigger books to be more like my dad. In particular, I remember two books: An Introduction to Quantum Physics and A Book of Abstract Algebra. I knew that next year I would have to take algebra and "physical sciences", and thinking these were the same subjects I wanted to get a head start. In doing so, I learned abstract algebra, and I tried as hard as I could to learn quantum physics.

Unsurprisingly, I ended up very lost, but I could follow many of the less technical discussions within the book, and I was AMAZED. Particles could pop into existence? Everything was waves? How on earth could people possibly know this was true?

It turned out that people knew these things because they could test it in particle accelerators, so since then I've had a really deep desire to SEE one in real life. Hence, CERN.

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*Other Prize(s) won at the ISEF fair this year:*

- *All-expense paid four week trip and scholarship to the Bessie Lawrence International Summer Science Institute.*
- *American Mathematical Society - First Award of \$1,000*
- *Mathematical Sciences - Fourth Award of \$500*

Last: **Ashmore**

First: **Elisabeth**

Country: USA

Age: 17

**Project:** Breaking the Silence

Until now, translating thought directly into action has been reserved to science fiction. In this cross-disciplinary experiment combining computer science and medical engineering, different approaches for EEG signal processing were evaluated to produce a brain-computer interface mouse emulator.

The BCI mouse was tested by volunteers performing point and click tasks while wearing an EEG headset. After multiple training and test trials, the testers were asked to fill out surveys.

Overall results were positive. Each of the volunteers was eventually able to move the mouse using only his mind power, although learning times were longer than anticipated. The performance of the emulator was 85% of normal mouse activity, and maximum cursor accuracy achieved 88%. Fully 87% of testers rated it a positive experience, and 89% would repeat the experiment.

There are many reasons for creating a BCI, but the most important reason of all is to give independence back to the most severely handicapped among us. Future research will include the addition of infrared control, so that these individuals can control their environment as well as their computers.

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**Motivation**

Technology impacts every aspect of our modern life. CERN interests me specifically because of the great technological strides being made there. The facilities and equipment used at CERN laboratories are beyond a doubt the most spectacular in the world. And the chance to learn about the fascinating things going on there motivates me to continue my own career in computer science.

The most important accomplishment in any scientific endeavor, in my opinion, is to make a positive impact. I believe CERN is extremely successful in accomplishing this. I have been fascinated by computers and programming since before I could even walk, but I am not one of those computer types who is mesmerized by technology for technology's sake. I want to learn how to use computers to make a real impact on people's lives. And with the opportunity to meet and learn from some of the most brilliant researchers in the world, I believe that I would be inspired to make that difference with my own research one day.

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*Other Prize(s) won at the ISEF fair this year:*

- *Computer Science - Second Award of \$1,500*

Last: **Budisteanu**

First: **Ionut**

Country: ROMANIA

Age: 19

**Project:** Using Artificial Intelligence to Create a Low Cost Self-driving Car

The purpose is the creation of an autonomous car which should be able to drive without any driver in the urban areas. In 2004 road accidents caused 2.5 million deaths worldwide and 50 million injured. Recent studies found that 87% of crashes were due solely to driver factors.

Two years ago, Google created the world's first self-driving car. The Google self-driving car problem is caused by using a very expensive 3D radar(\$75,000), with a high resolution to create a 3D map. My solution is a minimal 3D radar that would only cost \$4000 and 3 special cameras mounted to recognize from images the traffic lanes, curbs and real time position of the car instead of the 3D radar

Parallel and distributed algorithms use AI to recognize traffic signs, demarcation lanes and to calculate using probabilities the position of the car on the road, where the roadsides are and to propose a new direction even in the absence of traffic lanes. They process data from a 3D radar, create a 3D map using OpenGL, using GPS coordinates and particle filters, localize the car on Google Maps, acceleration sensors with Neural Networks, a supervisory system which drives the stepper motor to turn the steering wheel

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## **Motivation**

Those who change the world are not programmers in industry but professors doing research in the field. Mathematics is older than 2000 years and the results were expected over many centuries. Great thinkers like Euler, the real discoverer of the Fourier transform or Maxwell the creator of the unification produced by the electrical and magnetic laws could not guess the value and impact of their achievements upon our society. On the other hand, computer science is new and those who created the theory and changed the humanity still live among us. Computer science has become a research tool for other sciences such as medicine, DNA, physics, chemistry, etc... None of such sciences has had such a major impact on humanity as computer science has. Computing has advanced exponentially over the past 40 years: people who have started their careers programming with punched cards are now working with supercomputers and dreaming about quantum computing. My motivation to apply for CERN is my passion about research, CS and to experience a scientific research facility. I would love to have the opportunity to be along with those who worked to change the world, being qualified to visit CERN.

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*Other Prize(s) won at the ISEF fair this year:*

- *Association for Computing Machinery - First Award of \$1,000*
- *Gordon E. Moore Award \$75,000*
- *Computer Science - Intel ISEF Best of Category Award of \$5,000*
- *Computer Science - First Award of \$3,000*

Last: **Cao**

First: **Vincent**

Country: USA

Age: 17

**Project:** Superconductivity Emerging from Diamagnetism and Non-Fermi Liquid Behavior in a New Class of Chalcogenides

Purpose, Problem, and Proposed Solutions- Heavy transition metal materials are currently among the most current and important areas in condensed matter physics due to strong spin-orbit coupling (SOC). SOC rigorously competes with other interactions, which generates unexpected insulating states in heavy transition metal oxides. However, when oxygen is replaced by a chalcogenide, novel states with more metallic characteristics may occur. It is this premise that motivates this study.

Conclusions- The simultaneous occurrence of superconductivity, linear temperature dependence of electrical resistivity, structural change, and diamagnetism in Ir<sub>3</sub>Te<sub>8</sub> suggests novel physics associated with SOC. This study provides motivation for furthering research on heavy transition metals and chalcogenides and opens avenues for new discoveries important for future technological applications.

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### **Motivation**

Physics has been my passion since the 8th grade. I have dedicated much of my time to condensed matter physics, yet my curiosity for scientific research drives me to explore other fields including high-energy physics research. At CERN, I will be exposed to cutting-edge research and world-class scientists, and this experience will give me insight into the very heart of science. I will be able to see how scientists interact with one another and what character traits and leadership skills allow scientists to prosper. This experience will give me further motivation for pursuing research and will allow to me to examine the origins of groundbreaking discoveries, especially the Higgs Boson particle. The most important trait I believe a scientist should master is the spark of curiosity; through CERN, I will be able to examine various scientists' curious manners and how their curiosity brought them to their success today. A visit to CERN will be a life-changing experience, in which the benefits will last for a lifetime.

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*Other Prize(s) won at the ISEF fair this year:*

- *Physics and Astronomy - Fourth Award of \$500*

Last: **Csele**

First: **Jennifer**

Country: CANADA

Age: 17

**Project:** Creating PEAS: Portable Elemental Analysis System

In order to detect and quantify the presence of heavy metal contamination in soil and plastics, a novel hollow cathode lamp (using a low-pressure discharge excited by both RF and DC energy) was constructed where the sample is the cathode. Sputtered material is excited and light is emitted at each element's analytical line (a wavelength unique to a particular element). Calibration was accomplished with samples of known contaminant concentration and data was graphed to reveal a logarithmic relationship between a signal-to-reference ratio and concentration. The lamp was then incorporated into a complete system in which a microcontroller controls gas pressure using a proportional-integral-derivative (PID) control algorithm, collects data from the spectrometer, and displays results on an LCD. Soil assays were performed on contaminated sites and comparison made to available assays. Plastic samples, included toys, were tested with some found to exceed the established safe-level of 90 ppm.

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**Motivation**

As the birthplace of a number of important discoveries, not to mention spin-off technologies such as the world wide web, a visit to CERN would be a truly awesome experience. I have always had an interest in physics and engineering, and I would love to have the opportunity to see the Large Hadron Collider not only for the physics it represents, but also the immense amount of engineering involved in the machinery itself! The discoveries at CERN have changed the way we think about and view the world, and has also has an effect on our day-to-day lives. I believe a visit would be an amazing, life-changing, motivational experience (dare I say, a "Disneyland" for budding physicists and engineers).

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*Other Prize(s) won at the ISEF fair this year:*

- *Google Thinking Big Award*
- *West Virginia University Renewable Tuition Scholarship Awards*
- *Physics and Astronomy - First Award of \$3,000*

Last: **Liu**

First: **Zeyu**

Country: CANADA

Age: 17

**Project:** A Novel Modular Repulsive Type Hybrid Magnetic Bearing for FES Systems

Flywheel Energy Storage systems (FESS) have many advantages over batteries. A key component of FESS are bearings that allow rotational energy to be stored. However, traditional mechanical bearings have issues like energy loss through friction and mechanical instability. This project highlights the construction and testing of an innovative hybrid magnetic bearing designed for FESS. To avoid energy loss, FESS use permanent magnets to provide most of the levitation while the electromagnetic bearings stabilize the system via PID control. The system is modular which allows for ease of maintenance and expansion. Tests demonstrated that the system is stable and resilient. The energy storage capabilities were improved when compared to conventional mechanical bearings. In future, it is likely that this hybrid system will increase the viability of FESS and enable the implementation of these systems as a main source of high capacity short-term energy storage in applications like electric cars.

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### **Motivation**

I have dreamed of going to CERN since I learned of this opportunity when attending ISEF in 2010. I'm fascinated by the prospect of seeing the LHC, one of the most amazing engineering projects in the world. I have a keen interest in how we can use magnetic fields to solve real world problems. I've used different magnets for my many of my engineering and science projects, but the 11 Tesla magnets are almost beyond my imagination. Seeing matter manipulated by magnetic fields on those scales would be a dream come true.

I've done experiments at home using materials and tools I found on e-bay or cobbled together myself. I've longed to work in a place where advanced technology and equipment are readily available so I can put my ideas more easily and precisely into practice. It's my lifelong dream of becoming an inventor and a world renowned engineer. As a high school grad, I hope to have the privilege of visiting a place where thousands of world class scientists and engineers call home.

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*Other Prize(s) won at the ISEF fair this year:*

- *K. Soumyanath Memorial Award - 1st Award of \$3,000*
- *European Union Contest for Young Scientists - Trip to the EU Contest*
- *Engineering: Electrical and Mechanical - Intel ISEF Best of Category Award of \$5,000*
- *Engineering: Electrical and Mechanical - First Award of \$3,000*

Last: **Pandya**

First: **Dhaivat**

Country: USA

Age: 15

**Project:** A Statistical Approach to Predictive Prefetching in Cloud-Backed Filesystems

My project uses artificial intelligence to reduce latency. Network filesystems obtain files from servers; files that are not in the cache take time. But, filesystems have a large amount of data about users' habits that is largely unused. The problem was to design algorithms that can predict file accesses and obtain the files in advance. This led me to create several predictive prefetching algorithms, a testbed system (PardusStats) that tested these algorithms over a large amount of user data, an ensemble learning system (PardusEnsemble) capable of pooling together sets of algorithms to react dynamically to changing user behavior and a cloud-backed filesystem (PardusFS) that implements the algorithms. Results show the new algorithms perform 80-100% better than existing systems on cache misses. Applications lie in greatly increasing the capabilities of low-power devices (e.g. phones), thin-clients as well as distributed processing tasks (e.g. physical simulation).

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**Motivation**

When I was nine years old, I used to play ping pong on Saturdays at the local senior centre. One of the members who I used to play with was a physicist (retired from the Los Alamos National Laboratory). Gradually, he introduced me to the curiosities of fractals and generating them with computers. As we were talking about the history of the internet (which he had lived to experience), he mentioned CERN and its role in creating the World Wide Web. From that day, I have harboured a dream to visit CERN. ISEF and my research have provided me with such an opportunity, and I don't want to miss it!

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*Other Prize(s) won at the ISEF fair this year:*

- *Association for Computing Machinery - Fourth Award of \$200*
- *Go Daddy - \$1,500 Open Source Award*
- *Computer Science - Third Award of \$1,000*

Last: **Parker**

First: **Ema**

Country: USA

Age: 15

**Project:** Germitron: Robotic Assessment of Seed Vitality

The robot "Germitron" was designed and built to assist in the assessment of seed vitality. Aspects of mechanical, electrical, hydrodynamic, software, and systems engineering were all applied in the design and construction of this robot. Nine modular 96-well plates were filled with absorbent material and seeds. Germitron administered the watering and periodic photography of the plates. Photography occurred at a specially designed station which used three servos to mechanically align each plate in the camera's field of view so that photographs taken at each 5-minute interval could be aligned with all the others to within a few pixels. The photographs were then digitally analyzed and archived to identify stages of seed germination for each seed. Vitality could then be assessed by more than simply the percentage of seeds in a sample that germinate after a couple of days. Rate of germination as well as rate of transition from one stage of germination to another could be determined.

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**Motivation**

CERN is one of the most dissimilar places on this planet from where I live. I was born in a small town in rural Utah which I live in to this day, but my thoughts are often farther away from this place even than CERN is. My mind goes to a place filled with unanswered questions driven there by an insatiable lust for knowledge, but not just any questions. I wonder about everything and nothing at all. At CERN these questions are being examined, but more than that. They are being examined in a culture that I have never known and can only begin to imagine its awesomeness. Science fair is my imitation of such inquisition. In my project looked at one question. To reach this question I had to go through all the nit picky little questions that made up the infrastructure of this problem. After months of hard work I had built a robot, programmed it, cut and glued, and pieced it together. And I found that figuring out how to ask the question is much more interesting than the answer itself.

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*Other Prize(s) won at the ISEF fair this year:*

- *Engineering: Electrical and Mechanical - Fourth Award of \$500*

Last: **Ramachandran**

First: **Ashwin**

Country: USA

Age: 17

**Project:** A Novel Mathematical Model of Cellular Apoptosis under the Influence of Hsp70

The focus of my project was to develop a mathematical model of heat-induced cellular death with a specific focus on heat-shock proteins (proteins induced in response to a stress) for applications in cancer therapy. My first step was to use the help of previous papers in order to derive two separate pathways which described the process of both cellular death and protein generation using bio-chemical equations to represent each step. I then used the Law of Mass action to derive a series of first order differential equations from those pathways. I was able to successfully create two models which, for the first time, gave insight into how heat can induce cellular death. My model predicted that heat induced cell death can be increased in cancerous cells by almost 80% if heat-shock proteins can be inhibited showing that the efficacy of the treatment can be vastly improved. Finally, I conducted an experiment in order to validate my results and achieved 98% validation when the experiment was plotted against my model. Overall, my results have the potential to revolutionize cancer therapy by making it both more effective and less harmful.

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### **Motivation**

From the first time I read about CERN in the novel Angels and Demons, I have been very keen to visit the birthplace of physical and technological marvels such as the World Wide Web and the Higgs Boson particle. While I am interested in other research occurring at CERN, I am most interested in the LHC. The LHC is a marvel of engineering, and its revolutionary discoveries have the potential to give us a good understanding of particle physics for the first time. The recent discovery of the Higgs Boson was particularly fascinating, because it validated the Standard Model and proved to be one of the most monumental discoveries in science so far. I find this research fascinating and will be pursuing it in the future. Recently, I read an article in the Wired magazine which recorded the amount of data generated by the LHC in one year. The numbers were astounding, and I believe that the enormous amount of data generated by the LHC is a direct representation of the knowledge which can be gained from it: it keeps going up. If given the privilege of being allowed to visit CERN through INTEL ISEF, I promise to make the most of the opportunity, for it would be one of my childhood dreams coming true.

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*Other Prize(s) won at the ISEF fair this year:*

- *Mathematical Sciences - Third Award of \$1,000*

Last: **Sarge**  
First: **Valerie**  
Country: USA  
Age: 16

**Project:** Novel Materials for Organic Solar Cells

Organic solar cells have become increasingly viable due to the high costs of traditional fuel sources and silicon solar cells. The current issue is that materials based on thiophenes (petroleum-dependent) and carbazoles (synthesis-intensive) are currently needed, but show low efficiencies. The proposed solution is to use furans, isolated from many agricultural sources, and produce a base for better electron donors. A three-member-ring furan quinone was successfully fabricated and the synthesis optimized, beginning from a furaldehyde and utilizing oxidation, substitution, and dimerization steps. The quinone has delocalized pi electrons and is predicted to exhibit pi-stacking. Thus, the derivatization of this base should create high-mobility donors for solar cells. Additionally, glass-substrate and plastic solar cells using traditional organics were tested and optimized, showing the applicability of these models for testing as well as the possibility of optimization of plastic cells.

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### **Motivation**

I am interested in coming to CERN because I love science, and particle physics has always been one of my favorite topics. The kind of organic chemistry that I am researching has everything to do with particles and kinetics; that's what electron flow is all about, and it's part of the reason that I got into the field. For me, science is all about understanding how stuff works. I love it when I finally understand a topic intuitively, and I live for that "aha" moment; I think that the kind of investigation done at CERN is incredibly close to the fundamental experimentation with how everything works. For me, visiting CERN would be an ideal opportunity to not only learn more about the topic and have an awesome experience, but also to get an idea of what this type of research is like. Additionally, having practically grown up hearing about discoveries at CERN, I think that visiting the place itself would be amazing.

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*Other Prize(s) won at the ISEF fair this year:*

- *King Abdul-Aziz & his Companions Foundation for Giftedness and Creativity - Fourth Award of \$1,500*
- *Energy and Transportation - Second Award of \$1,500*

Last: **Soliman**

First: **Yousuf**

Country: USA

Age: 16

**Project:** IlluminaMed: Developing New Artificial Intelligence Techniques for the Use In a Biomedical Image Analysis Toolkit

In order to standardize and accelerate biomedical image analysis, I developed IlluminaMed, software that uses my new artificial intelligence techniques to automatically segment MRI scans, find tumors, discover lesions in multiple sclerosis and ALS, and determine the likelihood of developing Alzheimer's by using corresponding EEG scans. The artificial intelligence developed include the optimization of current fuzzy logic techniques and the development of new artificial neural networks that can create more abstract patterns and more powerful associations. My software can also correlate the probability of a specific diagnosis with brain structure and activity patterns. Currently, IlluminaMed is in the process of being implemented into several universities and hospitals for use by both researchers and physicians.

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### **Motivation**

I have always been fascinated by the world around me which has led me to try to understand the inner workings of both the human brain and the universe we inhabit. This curiosity has incited me to go after new opportunities that allow me to gain a new outlook on the world around me and continue to motivate me to further my research and pursue new advancements in science. To visit the largest organization pioneering the new frontiers of science, CERN, would be a dream of mine come true. To be able to meet with some of the most brilliant minds would be an awe inspiring experience that would undoubtedly propel me to further my research and extend it applications. For me, CERN is a role model of scientific research where multiple countries overcome political barriers to extend the realm of our knowledge. To visit CERN is an experience that certainly will change my life as well as provide me another perspective into the ever growing and changing field of high energy physics.

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*Other Prize(s) won at the ISEF fair this year:*

- *Arizona State University - New American University Provost Scholarship*
- *Google CS Innovation Award.*
- *Computer Science - Second Award of \$1,500*

Last: **Tschopp**

First: **Fabian**

Country: SWITZERLAND

Age: 20

**Project:** Building and Programming of a 3D-Scanner

Building and Programming of a 3D-Scanner

Various 3D techniques have recently been used in televisions, cinemas and 3D printers. These applications make the use of 3D scanners more important. The goal of this work was to develop a 3D scanner which is able to scan objects and visualize them in 3D on a computer.

This approach uses a line laser module, a customary USB webcam and a turntable powered by a stepping motor. The development of novel algorithms for picture filtering, camera calibration and surface reconstruction was necessary in order to achieve high accuracy. Before building the hardware, a 3D simulation software was designed to compute the optimal physical parameters of the scanner.

The finalized 3D scanner consists of a scanner prototype, computer software for the scanner and the documentation. The scanner outperforms similar commercial solutions in terms of both features and quality. Per scan, up to 9GB of picture material is being processed. This leads up to 1,300,000 vertices per object. Color information can be captured during a second scan and is directly mapped onto the 3D mesh.

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### **Motivation**

Even though I live in Switzerland, I have never been able to visit the CERN. Next to interests in computer science, I am also very interested in modern physics and machine engineering. This is also reflected in my project, which is interdisciplinary over mathematics, physics, computer science, geometry and engineering.

And finally, my focus classes in high school were mathematics and physics.

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*Other Prize(s) won at the ISEF fair this year:*

- *Computer Science - Second Award of \$1,500*