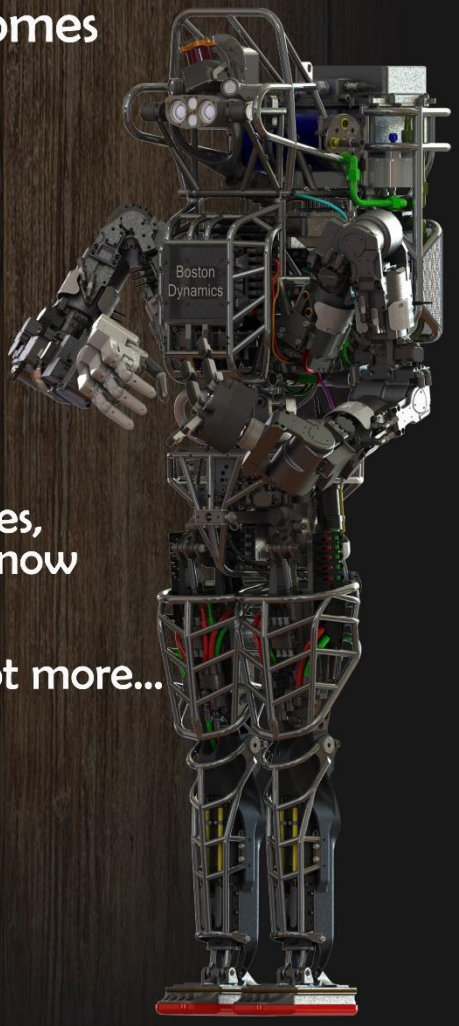
LIVE WIRE

August 2014 Issue

PHOENIX

THE ECE, EEE AND EIE ASSOCIATION

" Leap with the big player into the future. Google has it all when it comes to jaw dropping robots.



" Quadcopters- the future of telecoverage

"Super conductors ? Old times, mate ! Its super capacitors now

" Fun facts, puzzles and lot more...

BOSTON DYNAMICS

BITS-PILANI, Hyderabad Campus

Department of Electrical Engineering

Office of 2013-14

28-Apr-14

Disclaimer: Some information has been collected from trusted sources. We are releasing it, believing it to be true to the fullest of our knowledge. Any discrepancies that may arise will not be the responsibility of the editorial board, PHoEnix, or the administration.

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FROM THE FACULTY-IN-CHARGE'S DESK

It gives me immense pleasure in writing this foreword for LIVEWIRE 4.0 - The technical magazine of PHoEnix.

My heartiest congratulations are with the editorial board for their diligent effort in putting up this issue. I would also like to appreciate the authors for their effort in contributing technically sound articles.

I sincerely request the readers to come up with more and more articles for the forthcoming issues. I wish that LIVEWIRE could be published at least biannually.

I wish all the best and pray for success for the PHoEnix association.

-Dr. Prasant Kumar Pattnaik

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FROM THE FACULTY-IN-CHARGE'S DESK

It gives me great pleasure in writing this note for the LIVE WIRE 2014. Having closely seen the making of LIVE WIRE, I can safely say that all the members involved have put in their best effort to release the magazine in due time. My congratulations are to them.

This year has been a great landmark for PHoEnix. PHoEnix was involved in organising events for ATMOS, Two IEEE sponsored workshops and many more events. This year, we also won "Best Technical Assoc" award presented during Pearl 2014. It was a great achievement and I sincerely hope that the next members of PHoEnix will take it to even greater heights.

Wishing all the success and hoping that the assoc will reinvent itself year after year,

A special thanks to all passing out batch students, who have contributed to the Assoc in on way are the other.

-Mr. Chetan Kumar V

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FROM THE EDITORIAL BOARD'S DESK

Livewire is the mirror of the perpetual hankerers of electronics of BITS-Pilani, Hyderabad Campus. It glimmers the sweat of electronics-soldiers that has already bled, and inspires amateurs for bleeding more in near future.

Welcome to the April 2014 issue of Livewire. As you digest its contents, you will observe that it is a veritable one-stop source of “hard” information for electronics and communication enthusiasts. From the latest news in the world of electronics to the future-controlling big players in the field of technology- all in one neat package- that is LIVEWIRE.

Directed to enthusiasts like yourself, who savour learning more about the latest developments in the world of electrical, electronics and instrumentation engineering, Livewire shows you what is new, how stuff works, how to use it, and construction plans for useful electronics devices.

This issue of livewire focuses primarily on latest trendsetters in the field of electronics, primarily robotics. We discuss about Google's Boston Dynamics and its landmarking robots like BigDog, Atlas, WildCat etc. Our primary focus lies towards drawing your attention to the possibilities of marvels that robotics, in particular, can do.

We also aim to channelise your enthusiasm to the formidable world of semiconductors, cognitive radios, transformers, the uses of IR spectroscopy towards waste plastic sorting, so on and so forth. The sprinkle of trivia, fun facts and puzzles shall keep your mood enlightened and ready to succumb to our electronic lullabies.

People usually wonder what is it in PhoEnix that makes it the best assoc, despite being the largest and toughest to handle. We explain why. Included inside are the glimpses from the joyous moments of 2013-14, a report of all activities that were organised by the office. There is a reason people succumb their jaws to gravity over PhoEnix, and we welcome you to the club!

We have tried our best to avoid all sorts of typographical errors; however we beg your pardon if anything failed to pass under our watchful eyes.

It was a really amazing time sorting out from the awesome entries sent by people from all over the campus. The effort that you have put in was commendable, and we would be obliged if you keep that up. We are open for all sorts of comments, help us improve, we promise you worthiness.

ELECTRONICS NEWS

(1)The Copenhagen Wheel

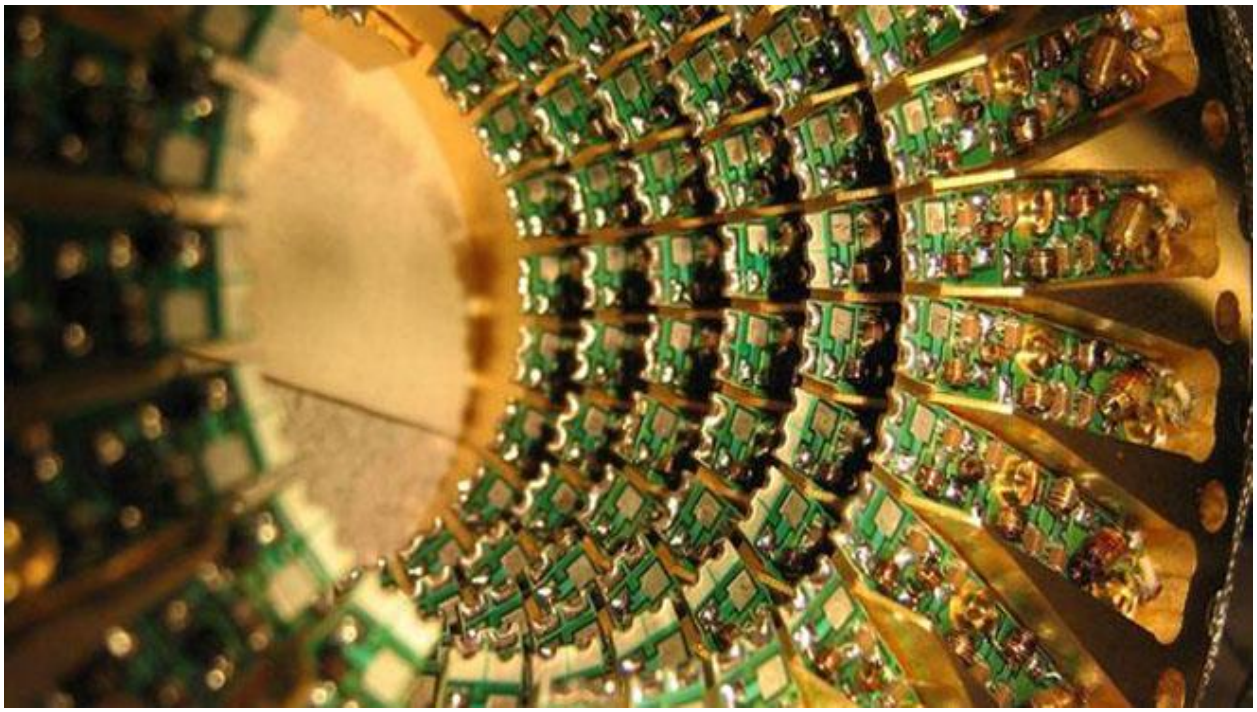
The Copenhagen Wheel is a seemingly simple wheel that transforms any normal bicycle into an e-bike. All that one has to do is to exchange one of the bicycle wheels with a Copenhagen wheel and your bicycle is no longer an ordinary one. This wheel saves the energy which is dissipated while pedaling and applying brakes and supplies it with the help of a motor, as and when required. This reduces human effort and provides an easy and eco-friendly alternative to other motorized vehicles. For example, when one has ride the bicycle uphill, increased effort goes into pedaling. In such a scenario, the wheel will deliver power to the bicycle and make the ride easier and faster. The Copenhagen wheel consists of a built-in electric motor and a 48-volts lithium -ion battery. And the most interesting part is that the Copenhagen wheel is controlled by a smartphone application.

Thus, using your phone one can lock or unlock your bicycle or change gears. One can also map pollution levels, traffic congestion and road conditions and thus decide upon the best route to the destination. The utility and flexibility of this wheel are such that one can even control how much the motor should assist the rider. It is a 26 inches wheel with Bluetooth connectivity and the operational on iOS and Android phones. Its speed can go up to 25km/h. The Copenhagen Wheel was unveiled on December 15, 2009 at the

COP15United Nations Climate Conference. The Copenhagen Wheel was initially developed at MIT's SENSEable City Lab as a research project, sponsored by the Mayor of Copenhagen. The company Superpedastrian is receiving numerous orders every day for this nature-friendly device. The Copenhagen wheel has definitely revolutionized urban mobility with its efficiency and versatility and has provided a practical and affordable alternative to cars and other vehicles that gradually degrade the quality of air around us and rob us of natural resources.

(2)Quantum Computer

Google's new quantum computer, D-Wave Two has brought the idea of commercial use of quantum computing into spotlight, though not in a very positive way. The D-Wave Two, a commercial quantum computer manufactured by D-Wave Systems was bought by Google in January 2014. However there has been growing speculation on whether the computer is actually able to exploit the quantum mechanical principles that would make the machine work much faster than regular computers.



The D-Wave Two machine works on the principle of quantum annealing, which is debatably, a part or rather a type of quantum computing. Google has so far used the computer to design a blink-detection algorithm for its Glass headset. Quantum computing is also expected to largely help in the field of astrophysics by analyzing data collected by satellites over a long period of time. Quantum computers use quantum bits, also called

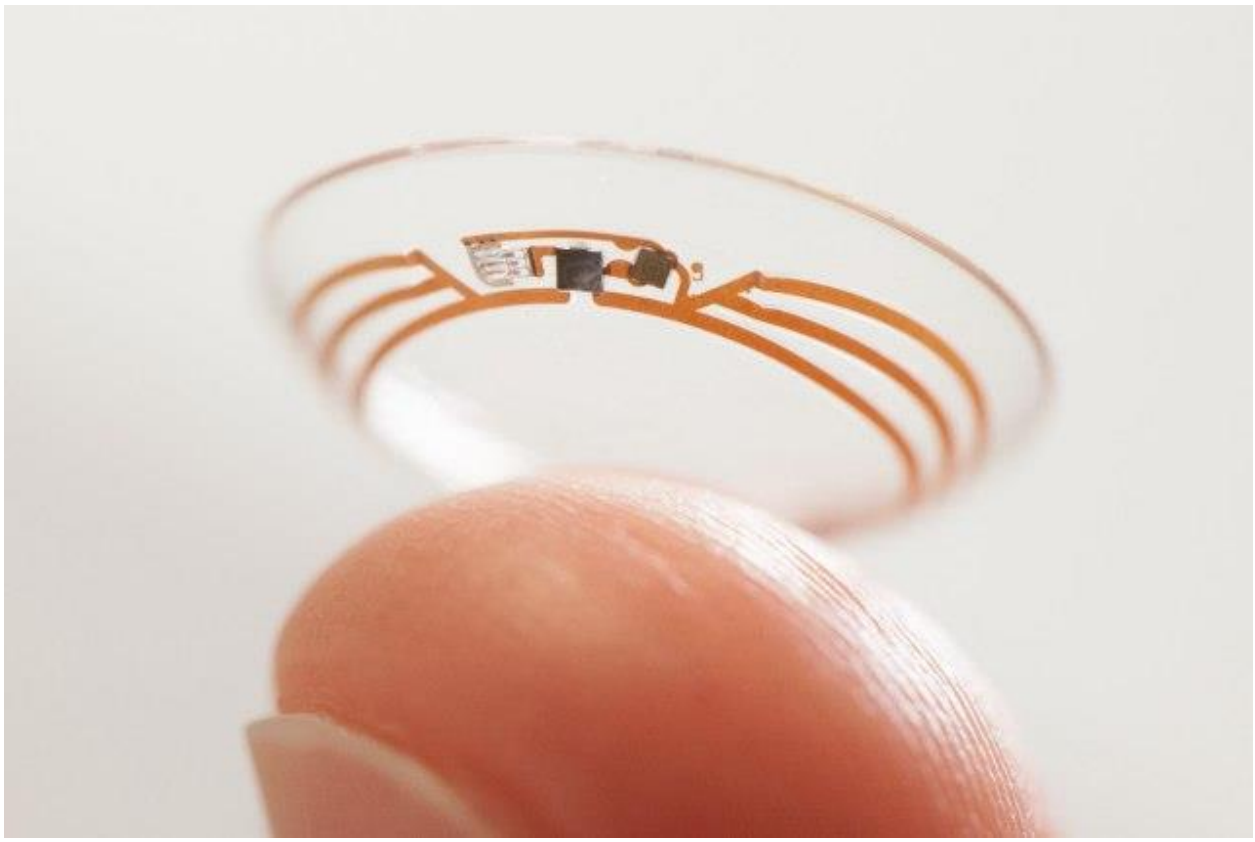
qubits that can be both 0 and 1 at the same time. This technology aids quicker solutions to problems where a large amount of data is to be manipulated or searched. However the speed-test that was conducted on D-Wave Two computer after it was bought by Google found no evidence of superior performance in it when compared to a classical machine working with an optimized algorithm (Troyer's test). However it is a wait and watch game now as Google believes that quantum computing is still in its early stages and more development in this field is expected with superior cores coming to market eventually.

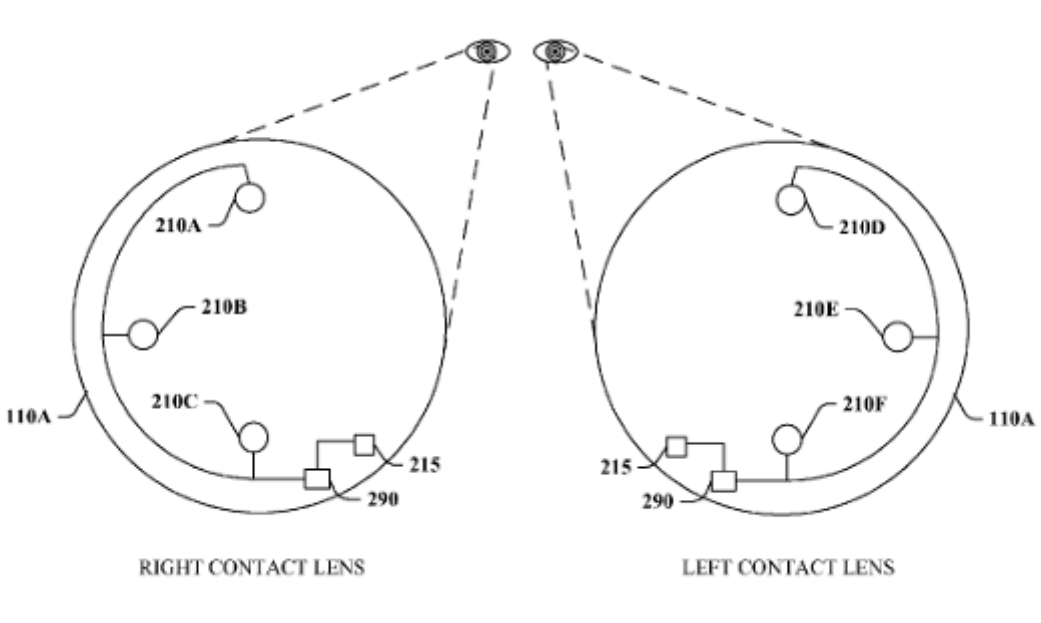
(3) Google contact lenses

"Google filed a patent application for a glass-like contact lens embedded with tiny cameras. The proposed smart contact lens could integrate a display that shows content from a web browser or application."

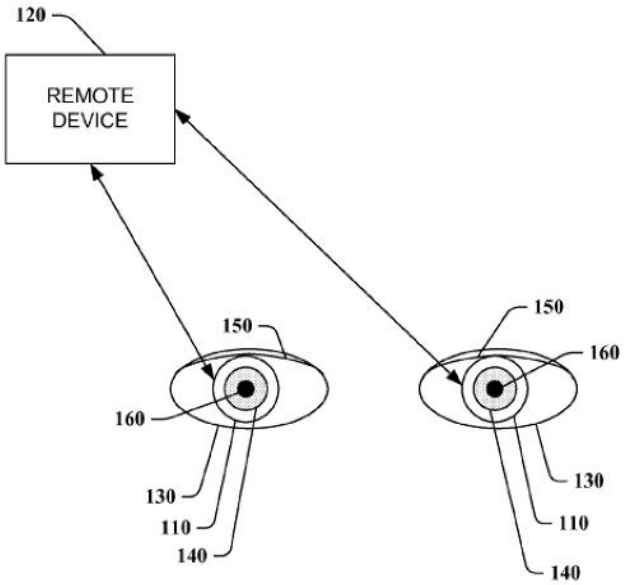
Imagine if Google Glass were invisible.

One of the major complaints against Google's futuristic heads-up display is that it's so obvious - even with redesigned specs. It appears the search giant already anticipated this critique, filing a patent application back in October 2012 that proposes embedding a contact lens with a display and tiny cameras.





The application published by the U.S. Patent and Trademark Office last week, highlights a wearable device capable of taking photos, storing them, and sending data to a remote device via a wireless connection. In addition, an integrated display can show information from the web and even guide blind people in their day-to-day lives.



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The smart contact lens could work with a remote device worn by the user, such as headphones, Google glass, hats, or clothing. It's possible the lens could also communicate with other electronic devices, like smart phones, cameras, laptops, tablets, TV sets, game consoles, or stereo systems. The application notes people could snap photos with the contact lens on a time interval, command from a remote device, or by blinking.

The lens is also capable of processing image data, including metadata related to objects. That means the smart contact lens, in theory, could guide a blind person crossing the street, detecting when one is approaching an intersection as well as cars in motion. It would then communicate with a remote device to let the wearer know via audio if it is safe to cross the street. To aid people with sight, the smart lens could flash LEDs to warn of oncoming cars when a person approaches an intersection.

Earlier this year, the Mountain View, Calif. Company's experimental division GoogleX showed off a smart contact lens prototype capable of monitoring the glucose levels of diabetes patients, warning them when their sugar levels dropped.

Report of Activities (until 22nd April '14)

Posters for all Laboratories in the Electrical Department:

The PHoEnix office of 2013-14 took initiative to fill up the notice boards of each lab with a brief description of what it is about and what it seeks to acquaint the students with. We prepared a total of 13 descriptions of labs operational at that point (August 2013) and put them up on the respective lab notice boards.

Freshers' Meet:

Date: 31st August 2013

The freshers were formally welcomed to the association on this day. The occasion was graced by the presence of both the Faculty-In-Charges of the association, Dr. Prasant Kumar Pattnaik and Mr. V Chetan Kumar. Along with the newly elected body, few of the ex-office bearers gave them the insights into the technical culture of the campus and encouraged the new members to add their value to the association. Followed by a long line-up of cultural events, the seniors and juniors interacted all along the way thus breaking the barriers to live together, work together and learn together in the coming years.

Newsletter release:

Date: 13th September 2013

The collective efforts of the Editorial Board took shape into the first newsletter of the academic year, released on the 13th September, 2013. The newsletter included the latest articles related to the fields of common interest of the students. The newsletter also gave insights to the events during Atmos'13 and their precursors.

PHoEnix Talks 2.1 (Orientation Session):

Date: 16th September 2013

A brief orientation session was conducted for all the students of the department (of Electrical Engineering) to familiarize them with the different fields of engineering dealt and the ongoing research being conducted by our department. The speakers for the session included Dr. S K Sahoo, Mr. Ananth Saradhi, Mr. V Chetan Kumar, Mr. M Gautham and Ms. P Spandana, who enlightening us about their research and the

subjects dealt by them in the curriculum. Presentations by Mr. Syed Ershad Ahmed were shared as well.

Pre-ATMOS workshop on Image Processing (by Dr. P K Thiruvikraman):

Date: 17th and 19th September 2013

The workshop on the bare basics of Image Processing and its practical implementations on MATLAB™ saw an overwhelming participation of about 350 students from all years. The workshop gave a very strong foundation to all the IP enthusiasts who led to the excellent run by our students in ATMOS as well as at other prestigious technical festivals.

Pre-ATMOS Events

Date: 5th October 2013

Image Processing (The Third Eye):

A simple problem statement pertaining to edge detection and 2 dimensional object detection was given to solve in a specific time. The competition saw a participation of about 20 teams. The top three teams were awarded cash prizes.

Line Follower (Follow the Line):

Follow the Line was organized to encourage budding robotics enthusiasts to showcase their mettle and challenge time and accuracy. Six 5 member teams faced off to be crowned perfectionists; the top two teams were rewarded for their efforts.

Pre-ATMOS workshop on Digital Circuits

Date: 6th October 2013

A group of 3rd and 2nd yearites took up initiative to introduce simple digital logic design to the 1st yearites and also a few effective techniques to deal with digital circuit building problems. The workshop had a hands-on session which exposed the participants to alien yet totally engrossing new concepts. The not for profit workshop conducted by the office bearers of PHoEnix witnessed a healthy participation (of about 25 teams).

ATMOS Events

Date: 11th, 12th and 13th October

Robowars:

This Headliner event of ATMOS-13 saw one of the largest audiences in the history of BITS-Pilani, Hyderabad Campus. With a participation of 10 teams, ranging from Jaipur (Rajasthan) to Chennai (Tamil Nadu) along with our own home team (The RPG), this was easily one of the biggest attention grabbers of the technical festival.

Open Micro Challenge:

OMC, recognized for its uniqueness as an event dealing with simple yet innovative electronic solutions to day to day problems (using Microprocessor Interfacing), drew a large chunk of participation from the overall audience of the technical festival.

Circuit Art:

Circuit Art, a digital circuit building competition known for its teasing simplicity hidden in complexity, saw a very decent participation of about 55 teams. The event that spanned across two days with two rounds inspired participants to treat real life problems the electronic way.

Paper Presentation:

ATMOS provided the participants an opportunity to showcase their ideas on a unique platform in the form of an integrated paper presentation. This PHoEnix event, stretched over 8 hours, on two days had a whopping turnout of about 220 participants from across the country. Select participants invited were judged based on the originality of the idea, the presentation and the technical details/results of the paper. Well, most of the prizes were bagged by BPHC students.

Technical Exhibitions:

A technical festival without an exhibition is completely unjustified. Hence, PHoEnix took up the initiative to develop the culture to exhibit our competence during the festival and introduced the Technical Exhibitions. Ten of the highest

quality projects were displayed as an effort to encourage students to take it up in the further editions of the technical festival.

Advances in Image Processing and Applications:

Date: 26th and 27th October 2013

The two day national symposium jointly organised with the IEEE student branch (BHPC), was sponsored by IEEE Hyderabad and IETE Hyderabad sections. The impressive list of huge names lined up for talks included Prof Madhavi Latha, Dr. C V Rao, Prof. Atul Negi, Dr. K Venugopal, Dr. B Sandhya, Dr R Krishnan, Prof B L Deekshatulu, Mr. R Ramachandran and Dr. P K Thiruvikraman along with Dr. K M M Rao (Course Director). The workshop also included an introduction to LABVIEW™ by National Instruments personnel, dealing little with image processing as well. This was the first symposia of its kind ever organised at BITS-Pilani, Hyderabad Campus utilised to brand PHoEnix at a national level. The workshop saw an immense participation from BITSians and non BITSians alike.

PHoEnix Talks 2.2 (The Art of Compacting Devices):

Date: 1st November 2013

The second edition of the talk featured Dr. Suman Kapur stressing on the importance of inter-disciplinary research and activities and its synergy. This was followed by a talk by Mr. Ambika Shankar and Ms. Sidrat Tasawoor on DNA Origami and a talk by Mr. Sai Phaneendra on Carbon Nanotube FETs.

Felicitation of Office Bearers (2011-12 and 2012-13):

Date: 1st November 2013

The office of 2013-14 took it upon them self to felicitate the previous office bearers. All the previous office bearers were invited, to which major portion of both the offices turned up. They were felicitated by the Faculty In-Charges of PHoEnix, Dr. Prasant Kumar Pattnaik and Mr. V Chetan Kumar.

Magazine (LIVEWIRE 3.0) Release:

Date: 1st November 2013

The first magazine of the academic year 2013-14, the third edition of LIVEWIRE, was released with efforts from the editorial board of the office of 2012-13 and the design team of the office of 2013-14. The magazine covered articles ranging from engrossing research to accelerometers and gyroscopes and fun stuff to do with

MATLAB™. To quote from the HODs message, "It is indeed a humongous task to motivate and collect technical articles from the faculty and student authors which the (2012-13) editorial board has done with extreme care and diligence."

PHoEnix Talks 2.3 (Time your analysis):

Date: 25th November 2013

A session to get a deeper understanding about timing analysis was conducted by Mr. V Chetan Kumar exclusively for 2nd and 3rd yearites. The talk saw an enthusiastic participation of about 120 students.

Advances in Video Processing and Applications:

Date: 9th February 2014

A one day national symposium jointly organised with the IEEE student branch (BHPC) sponsored by IEEE Hyderabad and IETE Hyderabad sections. The topics taught varied from the very basics of video formation, perception and representation to complex topics such as motion estimation and super resolution techniques. The speaker line up as impressive as ever included Prof. Kaluri V RangaRao, Prof. B Chakravarthy, Prof. V S K Reddy, Prof. P K Thiruvikraman, Prof. Shafee Sayyad and Dr. K M M Rao (Course Director). This symposium saw a participation of around 150 students. PHoEnix as a co-organiser of the symposium gained notice at the national level.

E Trade:

Date: 15th March 2014

The trademark general quiz cum hands on circuit building competition retained its fame as one of the most absorbing events on campus. An excited 25 teams fought it out at the event making it a grand success.

PHoEnix Talks 2.4 (Talk on MS opportunities and Placements):

Date: 22nd March 2014

The most awaited talk on placements and MS Opportunities was "worth the wait" according to attendees. The speakers included Mr. Nitin Suresh, Mr. Soumya Ganguly, Mr. Garvit Maini, Ms. Dedeepya Annabathuni and Ms. Aarushi Girdhar. They gave constructive opinions and considerate tips to prepare for placements and for applying to Universities for MS.

Wireless Transfer of Information Using Radio Frequency:

Date: 5th and 6th April 2014

The no prerequisites workshop on basic communication protocols was conducted by DigiMindIndia. The workshop covered the basics of microcontrollers, display devices and communication protocols. Serial communication using Arduino and wireless communication using RF modules were later explained, using which participants were made to develop a basic chat application using the same. Home automation with infinite control range was also dealt. The workshop had about 40 participants from all years.

Farewell for the classes of ECE and EEE 2015:

Date: 21st April 2014

To bid their final goodbyes to the class of 2015, the 2nd yearites organised a farewell party. The event started off with a welcome song. An informal talk by Mr. V. Chetan Kumar lightened up the entire crowd. A variety of events were lined up for the batch of 2015. Many people were awarded for various categories. It was essentially a platform for the seniors to open up and share their feelings about their life on the campus. The event was followed by dinner and distribution of mementos.

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P.Pujitha

THE QUADCOPTER WORKSHOP

-Shubham Bhardwaj

We all are aware of the enthusiasm we overflow with, when we decide to enter an engineering college. This brimming talent, with a proper nurture may lead to dramatically whelming results. A fine example was put up by a recent workshop organised in BITS-Pilani, Hyderabad Campus.

"Quadcopter", I overheard what I needed to, in someone's regular "mess-talks". Upon checking the shoutboxx*, I found out that Robosapiens, in association with IIT-Delhi was going to organise an event called "RoboTryst", for which they arranged workshops in brimming engineering colleges across India. They intended to select prodigies from colleges to compete in the quadcopter competition in RoboTryst, 2014.

The workshop started with an excruciating accent (excuse please), yet the topic kept us glued to the lecture theatre complex from 2 pm to 11 pm. It started with basics of electronics, slightly moved on to more technical aspects. They covered the theoretical part on day one. Over enthusiasm mixed with a detail of every aspect from design, operation, electronics to calibration and control of the copter was taught on the first day. Five out of ten teams were asked to assemble their designs on the very first day. We almost were able to fly, but caliber one copter on the very first day, to our astonishment. We were divided in teams of five each, the kits were externally provided.

The role of the calibration of the three axes in the flight of the copter, the role of symmetry in design, the role of firmwares was made clear to us. Light was shone on how to code the Atmega16 for the process of flying a quad. The second day was test time, we were given questions to solve, and our quads were judged in terms of design and flight. Teams were selected from our college to represent BITS-Pilani in the competition. Lodging, boarding and dearness were promised by robosapiens.

Overall, it was an experience of great zenith, we learn a lot. The workshop opened up gates of a new world of study, enthusiasm, and boasting off to the opposite gender.

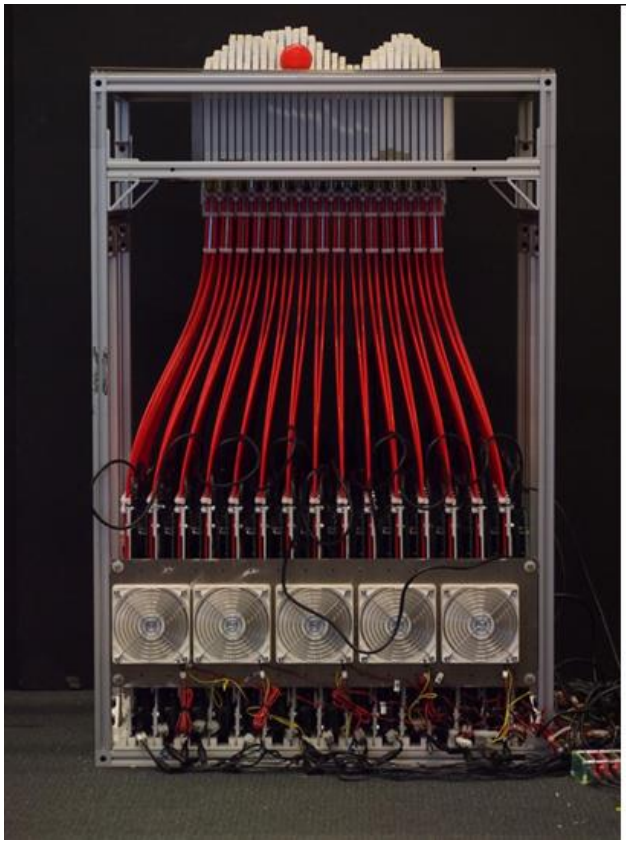
To sum up, I would like to quote Confucius, the great Chinese philosopher,

"I hear and I forget. I see and I remember. I do and I understand."

inFORM

Interacting with a Dynamic Shape

-Harshit Singh



The future of the Web, it seems, is not just sending data but transmitting actions. Telepresence robots and remote-control drones already let an internet user in one place control far-off gadgets in the physical world. Now another such device has emerged on the scene—a dynamic display that transmits 3-D shapes from the sender to the receiver.

The device is called inFORM, a "dynamic shape display" developed by researchers at MIT (Tangible media Group, led by Prof. Hiroshi Ishii. Think of it as a long, wireless line of communication. On the receiving end of this line is a surface comprised of 30 by 30 pins. Each pin has a tiny motor attached to its base, which can move it up and down independently of the 899 others. On the other end of the line, a depth-sensing camera records physical objects or movements and sends that information to the motorized surface.

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Each of the pins acts as a three-dimensional pixel to recreate that information in a physical form. A projector mounted above the surface provides context to the shape

shifting pins, giving them color and highlighting depth. When used in conjunction with a Kinect sensor, inFORM gets a lot more interesting. The sensor is able to accurately map and interpret the position of 3D objects. It essentially makes the 3-D vision pop up from the surface.

This may all sound kind of confusing and obscure, but think of it this way: it's like a cross between Skype one of those bizarre, '90s pin-art toys.

"It's extremely impressive stuff, but it's just one step on a long path to what MIT calls Radical Atoms. First conceptualized over a decade ago, Radical Atoms is what MIT believes will be the future of interactivity. The idea is that we presently interact with computers through graphical user interfaces (GUI), while inFORM and other projects like it offer up a tactile user interfaces (TUI)."

MIT likens TUIs to a digital iceberg: just the tip of the digital content emerges "above water" into the physical realm. Moving past TUIs, the end game is Radical Atoms, a future in which "all digital information has physical manifestation ... as if the iceberg had risen from the depths to reveal its sunken mass. The list of potential applications inFORM's developers foresee is nifty and far-reaching: from 3-D visualizations of CT scans, via interactive terrain models for urban planners, to long-distance design sessions between collaborating architects. But to make these applications practical, the resolution will need to be ramped up significantly. Future iterations of inFORM will have to include far more pins and far greater control. It won't be long when dual world of bits and atoms will be seamlessly coupled by giving physical form to digital information.

innovate achieve lead

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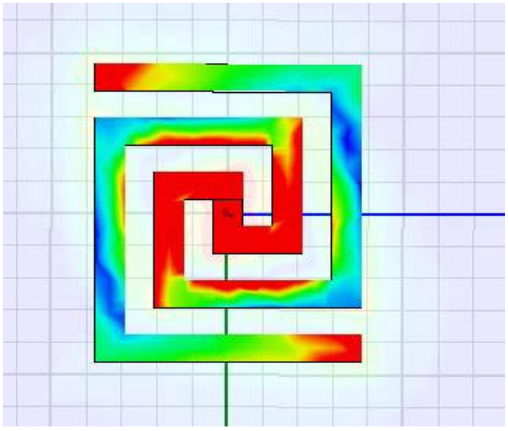
THE EVOLVED SOLAR CELL

-Rohith Mulugu

Antenna is an indispensible component in wireless communication, which is so ubiquitous that we cannot think of our modern life without this. A lot of work has been done on antennae in the radio frequency (RF) range. With ever-increasing demand for reducing space, increasing speed and reducing power requirements, the technology has taken a leap from microscale to nanoscale thereby giving rise to nanotechnology. The advent of nanotechnology thereby reducing size and increasing speed of the electronic devices has compelled the antennae to scale down to nanoscale to gain compatibility with the developing technology. New energy harvesting technologies have drawn interest in recent years for both military and commercial applications.



Flow of THz currents to feedpoint of antenna. Red represents highest concentrated E field. Modelled with Ansoft HFSS.

Traditional p-n junction solar cells are the most mature of the solar energy harvesting technologies. The basic physics of energy absorption and carrier generation are a function of the materials characteristics and corresponding electrical properties. A photon need only have greater energy than that of the band gap in order to excite an electron from the valence band into the conduction band. However, much of the solar radiation reaching the Earth is composed of photons with energies greater than the band gap of silicon. These higher energy photons will be absorbed by the solar cell, but most of the energy is converted into heat rather than into usable electrical energy. For a single-junction cell this sets an upper efficiency of ~20%. The current research path of implementing complex, multijunction PV

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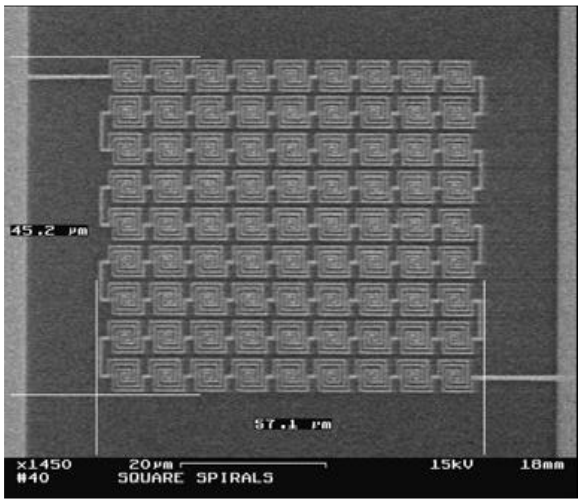
designs to overcome efficiency limitations does not appear to be a cost-effective solution. Even the optimized PV materials are only operational during daylight hours and require direct (perpendicular to the surface) sunlight for optimum efficiency.

With the advances in nanotechnology, optical nanoantennas have generated increasing research interest due to their ability to :
i) Strongly enhance and confine the optical fields to very small dimensions, surpassing the diffraction limit, and
ii) Strongly enhance and direct radiation from localized optical sources into the far field.
These abilities enable a large number of potential leading-edge applications in nanoscience. Some deep reviews of the basic principles and potential applications of optical nanoantennas can be found in this report.

The first concept of optical nano-antenna was put forward by K.B.Crozier group of Standford University referring that nano-photonic device which couples optical-frequency electromagnetic waves to sub-wavelength scale effectively by using surface plasmon effects, is capable of achieving nanometer focus and providing the possibility of nanometer scale optical information treatment and transmission. There shows many inviting application prospects in the fields of microscope's super-resolution.

There is a new efficient approach for producing electricity from the abundant energy of the sun. A nantenna electromagnetic collector (NEC) has been designed, prototyped, and tested. Proof of concept has been validated. The NEC devices target mid-infrared wavelengths, where conventional photovoltaic solar cells are inefficient and where there is an abundance of solar energy. The initial concept of designing NEC was based on scaling of radio frequency antenna theory. This approach has proven unsuccessful by many due to not fully understanding and accounting for the optical behaviour of materials in the terra-Hz region. Also, until recent years the nanofabrication methods were not available to fabricate the optical antenna elements. Several factors were critical in successful implementation of NEC including frequency dependent modelling of antenna elements; selection of materials with proper THz properties; and Novel manufacturing methods that enable economical large-scale manufacturing.



An array of nantennas, printed in gold and imaged with a scanning electron microscope. The deposited wire is roughly a thousand atoms thick. A flexible panel of interconnected nantennas may one day replace heavy, expensive solar panels.

The work represents an important step toward the ultimate realization of a low-cost device that will collect, as well as convert this radiation into electricity, which will lead to a wide spectrum, high conversion efficiency, and low-cost solution to complement conventional PVs. The NECs can be configured as frequency selective surfaces to efficiently absorb the entire solar spectrum. Rather than generating single electron-hole pairs as in the PV, the incoming electromagnetic field from the sun induces a time-changing current in the antenna. Efficient collection of the incident radiation is dependent upon proper design of antenna resonance and impedance matching of the antenna. Recent advances in nanotechnology have provided a pathway for large-scale fabrication of nantennas.

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ALL ABOUT SUPERCAPACITORS

-Sumiran Shubhi

All of us have certainly heard of super conductors, haven't we? Superconductors are materials which will allow charges to flow without any resistance to their path under certain conditions. Now let's explore what supercapacitors are.

Super capacitors, as the name suggests can store tremendous amounts of energy, when compared to a regular capacitor. This implies that a supercapacitor has a very value of capacitance. For example, a typical electrolytic capacitor will have capacitance in the range of tens of millifarads. A supercapacitor of the same size will have capacitance in the range of farads, which is an improvement of three orders of magnitude.

Supercapacitors are also known as ultracapacitors or electric double-layer capacitors (EDLC). Supercapacitors, unlike regular capacitors, do not have a layer of dielectric substance between two conducting plates. These capacitors use plates that are two layers of the same substance. Here the electrostatic storage happens due to the formation of a Helmholtz double layer wherein the physical separation between the layers is of the order of nanometers. Due to this absence of dielectric layer the utility and packing efficiency of supercapacitors get enhanced for several practical purposes. Activated carbon is the primary substrate used in double layer capacitors.

The specific power as well as its lifetime (1 million of charging-discharging cycles) makes super-capacitors a lucrative option for use in automation. These capacitors can be charged very quickly due to low internal resistance. However, they get discharged pretty soon, as well. SCs can be very useful in cases where a large number of charging/discharging cycles are required in a very short time and one does not have to compromise on the longevity of its lifetime either.

Supercapacitors are used in a variety of fields. Supercapacitors can stabilize power supply wherever the load is fluctuating such as laptops, PDA's, media players etc. It delivers power to photographic flashes of digital cameras. It also provides emergency power back up to low power devices such as RAM, SRAM, micro-controllers and PC cards. It can stabilize voltage for power lines in the cases where renewable sources of energies are used. Owing to its high power density it is widely used in military related equipments like phased array radar antennae, laser power supplies, military radio communications, avionics displays and instrumentation and GPS-guided missiles and projectiles. Supercapacitors find applications in aviation, railways and medical field as well.

Until recently, the supercapacitor market has grown largely at the expense of conventional capacitors. Currently, the technology seems ready to invade the lithium-ion battery market used in smart phones and other devices.

The total potential energy content of lithium batteries drops if energy is extracted quickly. In other words, demand for immediate high power from the battery means that less total energy can be extracted than if the same amount of energy was extracted over a longer period of time. Supercapacitors do not have this limitation.

Instead of activated carbon which is commonly used in supercapacitors electrodes, biochar can be used as it is in sync with the sustainable and green environment objectives that we are trying to achieve. Unlike activated carbon, biochar is non-toxic and will not pollute the soil when dumped. Added to this is the low-cost factor of biochar as it costs almost half as much as activated carbon.

Initially, supercapacitors were only used in applications such as memory protection and internal battery backup, but in the last few years the scope and versatility of its usage have increased remarkably since now it is being used in hybrid vehicles, smartphones and energy harvesting. The increasing demand of supercapacitors in various fields thus gives positive indications about the advancement and availability of new technologies in every dimension of human development.

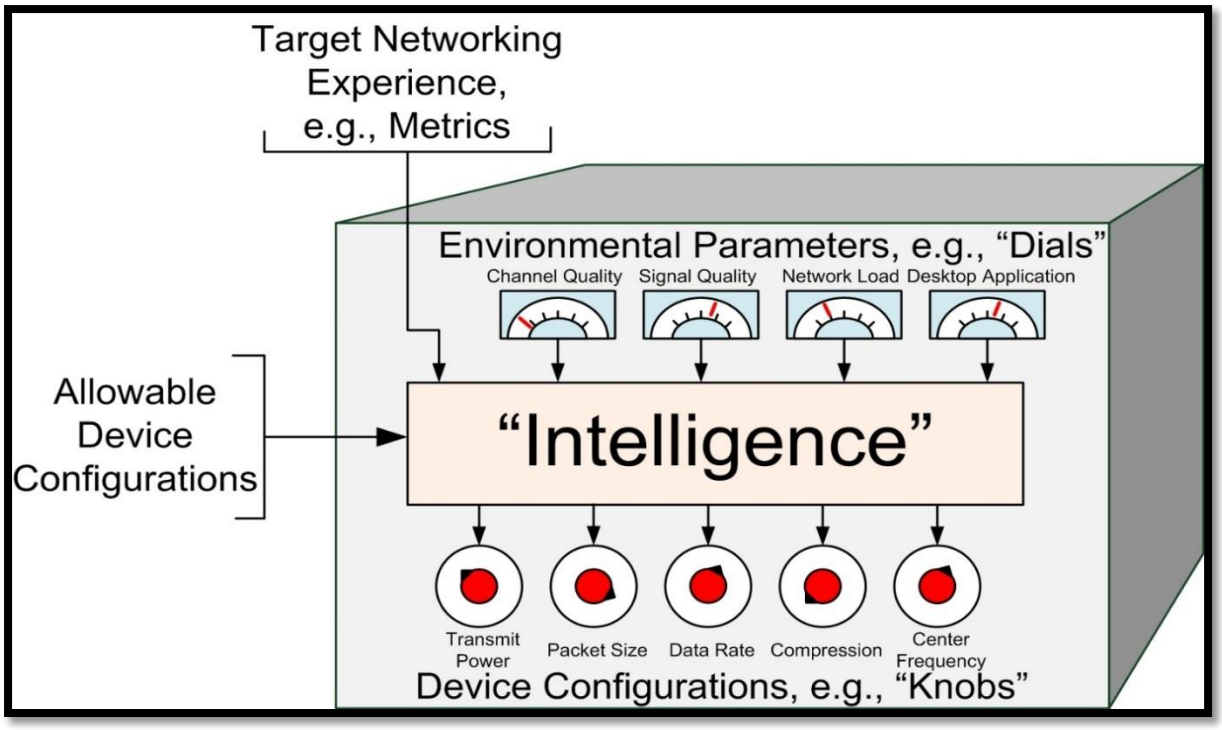
Cognitive Radio

-Akash Raj

In a world of increasing mobility, there is a growing need for people to communicate with each other and have timely access to information regardless of the location of the individuals or the information which makes wireless systems of prime importance in today's technological era. Efficient utilization of the physical radio spectrum is a fundamental issue of wireless communications. The conventional licensed methods of frequency allocations are overly uncompromising, resulting in both spatially and temporally ineffective usage of radio spectrum. Also the demands for wireless communication have increased significantly in terms of number of users and quality as well. Most of today's radio systems are not aware of their radio spectrum environment as they are designed to operate in a predefined frequency band using a specific spectrum access system The conflict between the inefficient usage of spectrum and the rapid growth

of wireless services calls for a more flexible and intelligent solution to manage such an important natural resource.

Cognitive Radio (CR), a new paradigm of wireless communication, has been considered as a potential way to accomplish such an important task.



Visualization of a Cognitive Radio

By combining the abilities of spectrum awareness, intelligence and radio flexibility, a cognitive radio will be able to adapt itself to the changes in the local environment. It is foreseen that a large amount of underutilized spectrum will be efficiently used by applying cognitive radio techniques. Previous schemes depended only on instantaneous measurement with the past experience being wasted. By exploiting machine learning techniques, such information can be used to facilitate the transmissions between entities. The goal is to incorporate the results of the learning engine into a predicate calculus- based reasoning engine so that radios can remember lessons learned in the past and act quickly in the future.

Cognitive radio is an intelligent wireless communication system that is aware of its surrounding environment (i.e., outside world), and uses the methodology of understanding-by-building to learn from the environment and adapt its internal states to statistical variations in the incoming RF stimuli by making corresponding changes in certain operating parameters (e.g., transmit-power, carrier-frequency, and modulation strategy) in

real-time, with two primary objectives in mind-highly reliable communications whenever and wherever needed and efficient utilization of the radio spectrum.

Learning algorithms are very useful when the dependence between the input and the output is unknown. For the cognitive which are based on software defined radios have a large number of configurable parameters and for arbitrary wireless channels it is not possible to know the interdependence between these parameters and thus it is difficult to determine these parameters simultaneously. Simple reason behind this is their complex interactions and impact on the RF environment.

Cognitive radios demand for re-configurability and also should autonomously operate in unknown and heterogeneous RF environments CRs may use learning algorithms as a tool for adaptation to the environment and to coordinate with peer radio devices. Moreover, incorporation of low-complexity learning algorithms can lead to reduced system complexities in CRs .They help the radio to derive knowledge from the observed data.

Predicting Whitespaces

Why Prediction? Spectrum allocation to an organization happens region-wise. Let us assume that a mobile device is on the move and it moves from region A to region B and is transmitting on a frequency spectrum f1. If there is a primary user which is transmitting on frequency spectrum f1 in region B, the mobile device is causing interference to these primary devices and hence has to stop using this spectrum and find an alternative. However, for now we assume that it is acceptable for the mobile device (secondary user) to use this spectrum if the primary user is not using it currently. Similarly, if the mobile

device is able to predict that there is another frequency that is/going to be free, it can use the alternate. So, this forms our rationale for prediction of whitespaces or rather the absence of it.

Predicting whitespaces will also help stationary devices when they are transmitting (or want to transmit) in a region and spectrum that is occupied by a primary user. Foreseeing the change in the power on that frequency, the device can choose its frequency appropriately.

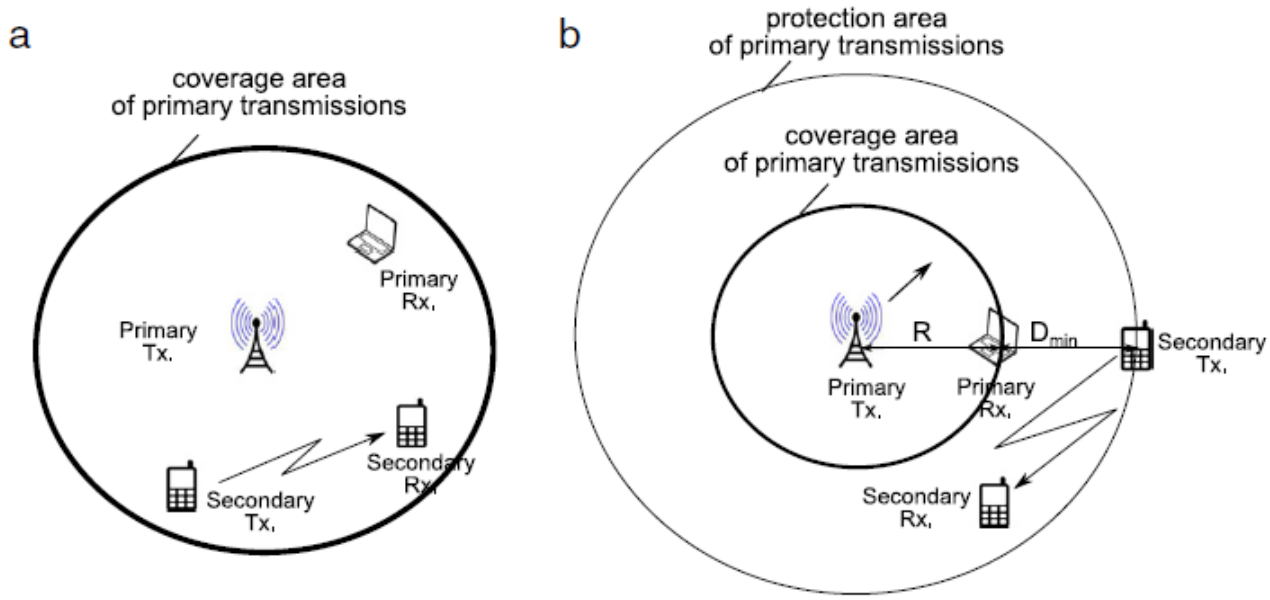
A New Model

As in many cooperative sensing scenarios, this prediction model (proposed) is one that involves a central node and multiple secondary nodes.

Central prediction

Local prediction at the secondary node itself

The feature set considered for this model involve time in seconds, minutes and hours, date involving day, month and year and the previous values. The features require a very huge dataset for training and the training should happen continually and over a considerably long period of time. This requires a lot of computational power and all secondary nodes can't be assumed to have such power. So, this prediction based on the time, day and location is done at the central node.



Types of spectrum holes

The centralized predictor tries to locate/predict patterns and periodic signal transmissions. This task is given to the central predictor because the data set involved is huge. The secondary node's prediction is purely based on the last feature which is, the most recent trend in power values. Consider an example to understand the scenario. Radio news stations use their allocated spectrum periodically and at more or less the same time of the day for months, or even years together. This is learnt by the central node which predicts the whitespace based on this periodic transmission. As we can see, this learning takes a lot of time and data and it is not feasible for the local nodes to do this learning. However, if there is an emergency broadcast to be made by the radio station, this cannot be predicted by the central node and has to be done by the secondary device itself. They monitor the most recent trend in power values and predict a future transmission on that spectrum. Note that this data is also sent from all the secondary nodes to the central node but it is just that the

prediction itself happens at the secondary node. A spectrum can be taken up by a secondary node if and only if it is predicted to be free at both the stages. On the other hand, the node should stop using the spectrum if either of the stages predicts that it is going to be used by the primary devices.

The proposed model is very promising and active research is taking place to improve the model and make it more efficient.

Cognitive radio is considered as a goal towards which a software defined radio platform should evolve- a fully reconfigurable wireless transceiver which automatically adapts its communication parameters to network and user demands. Cognitive Radio technology is currently to trying to address the global wireless bandwidth crisis.

Transformer – The Heart of Alternating Current

-Manasi Muglikar

It all began in the year 1830. The property of induction was discovered in early 1800 by Michael Faraday but it wasn't until 1886 William Stanley built the first refined, commercially used transformer .Lucian Gaillard and Sebastian Ferranti along with William Stanley perfected the design. In the early 1970s unit rating as large as 1100MVA were produced and 800KV and even higher KV class transformers were manufactured in year of 1980.The first AC power system that used the modern transformer was in Great Barrington, Massachusetts in 1886.

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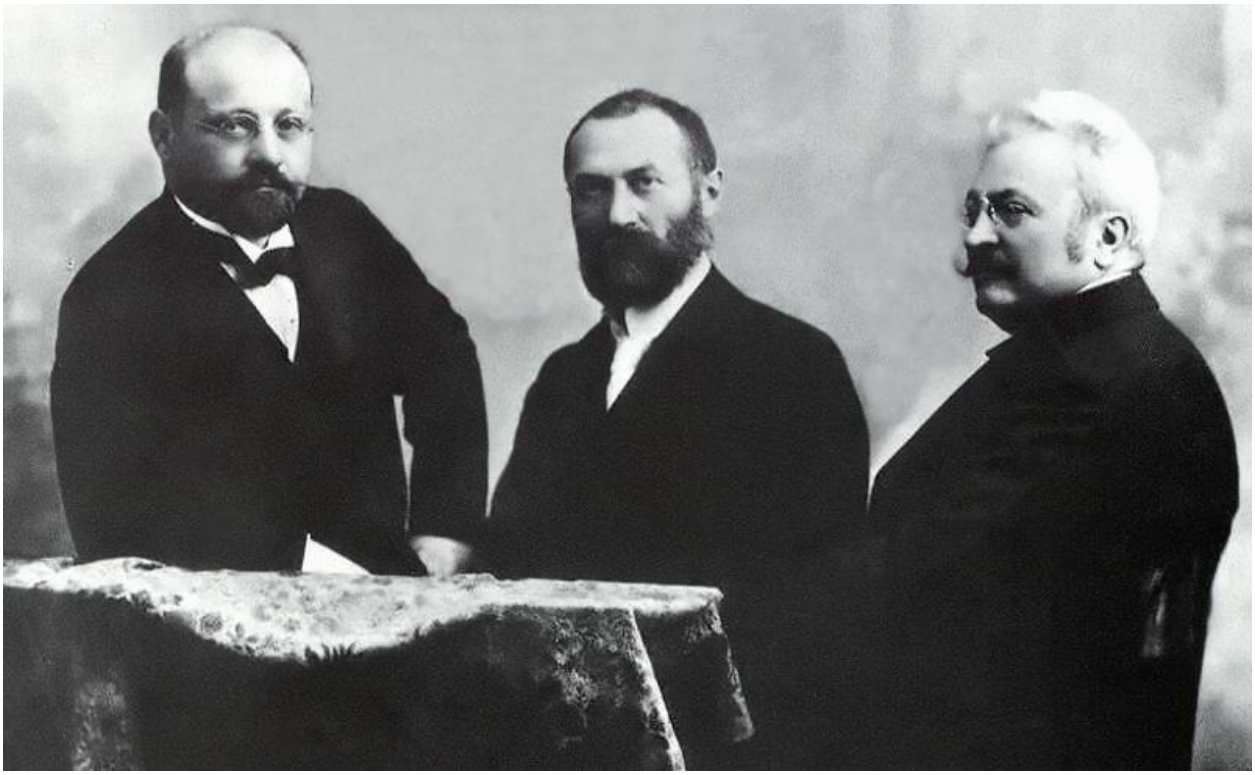
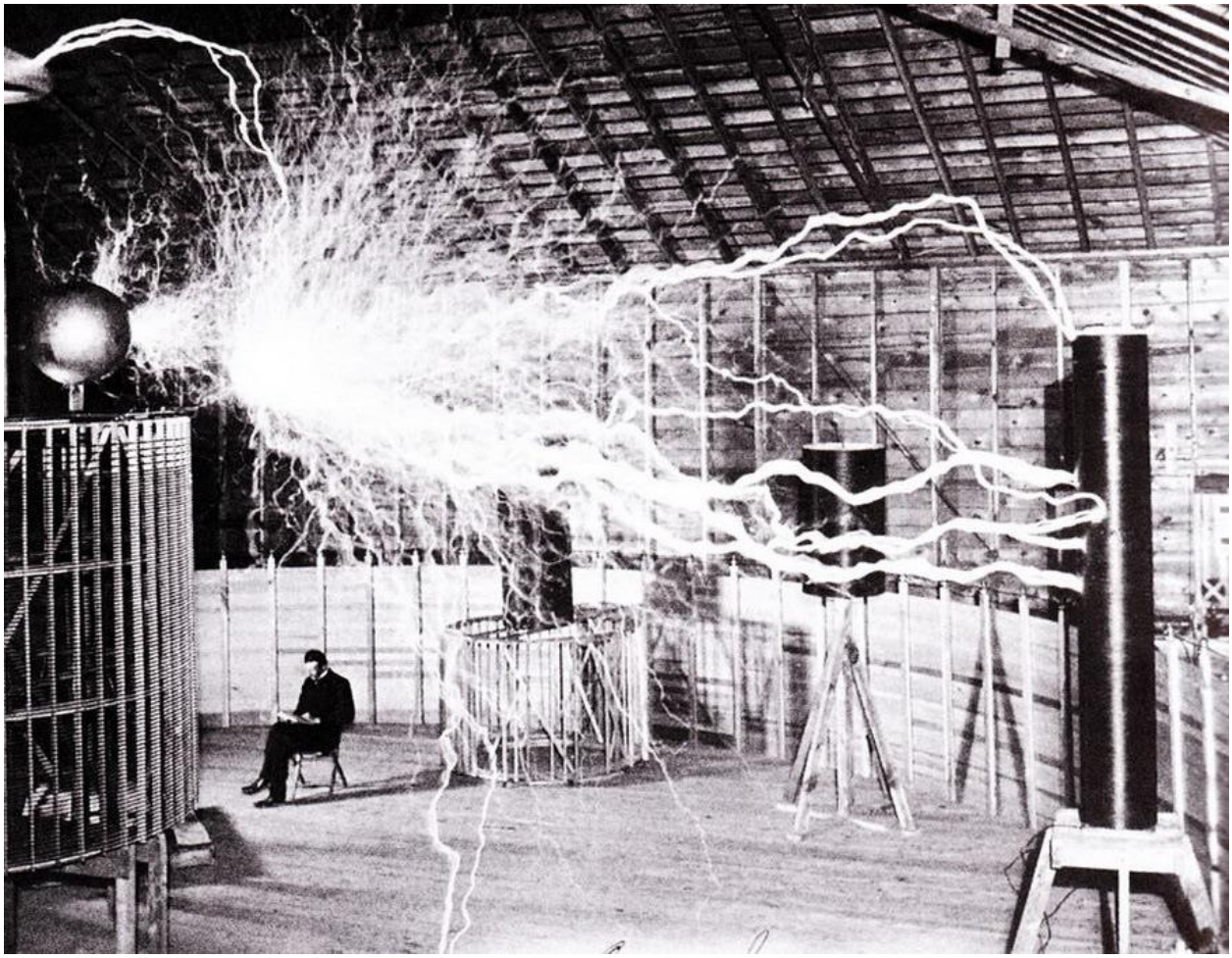


Necessity –the mother of invention

DC was mainly used earlier and is hard to transmit over long distance. High voltage on DC is very dangerous, and with low voltage the wire would have to be so thick that it would not be practical. Also with high voltage you couldn't step down the voltage so it could be used for equipment with lower power ratings.

With AC power you can use high voltage to move electricity along a long wire.AC becomes practical because once the power is sent you can you a transformer to adjust the voltage to manageable levels.



Electrical Power Transformer is a static device which transforms electrical energy from one circuit to another without any direct electrical connection and with the help of mutual induction between two windings. It transforms power from one circuit to another without changing its frequency but may be in different voltage level. Actually mutual induction between two or more winding is responsible for transformation action in an electrical transformer.

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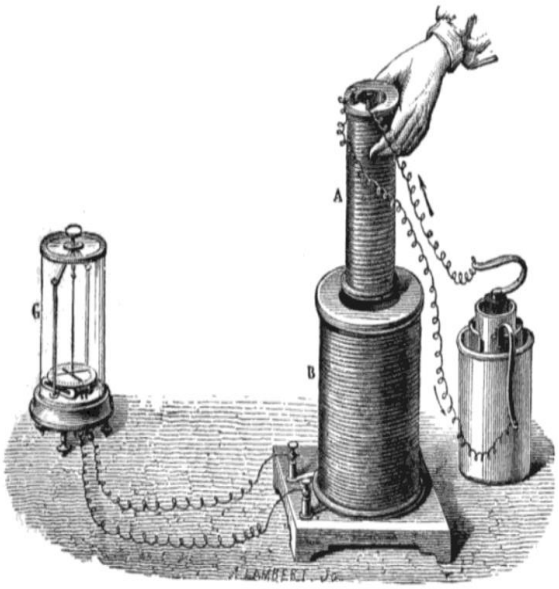

Faraday's experiment on induction on two coils.

Invention of Transformer: how one thing led to another?

Faraday's experiment played a pivotal role in the invention of transformers. He devised the concept of lines of force which later on helped in discovering about mutual magnetic induction by noting the change current in a wire when the current was turned on and off in a second wire on the same toroidal core. Then came Hans Oersted who completed the theory of quasi stationary electromagnetism. The transformer had a fundamental feature that Faraday had missed, the generators capacity to adjust load and current to adapt them to load requirements. In America the pioneer of transformer was William Stanley.

Basic Principle of Transformer

The functioning of a transformer is based on two principles of the laws of electromagnetic induction: An electric current through a conductor, such as a wire, produces a magnetic field surrounding the wire, and a changing magnetic field in the vicinity of a wire induces a voltage across the ends of that wire.

The magnetic field excited in the primary coil gives rise to self-induction as well as mutual induction between coils. This self-induction counters the excited field to such a degree that the resulting current through the primary winding is very small when no load draws power from the secondary winding.

The physical principles of the inductive behavior of the transformer are most readily understood and formalized when making some assumptions to construct a simple model which is called the *ideal transformer*. This model differs from *real transformers* by

assuming that the transformer is perfectly constructed and by neglecting that electrical or magnetic losses occur in the materials used to construct the device

Transformers applications:

Transformers perform voltage conversion; isolation protection; and impedance matching. In terms of voltage conversion, transformers can step-up voltage/step-down current from generators to high-voltage transmission lines, and step-down voltage/step-up current to local distribution circuits or industrial customers. The step-up transformer is used to increase the secondary voltage relative to the primary voltage, whereas the step-down transformer is used to decrease the secondary voltage relative to the primary voltage. Transformers range in size from thumbnail-sized used in microphones to units weighing hundreds of tons interconnecting the power grid. A broad range of transformer designs are used in electronic and electric power applications, including miniature, audio, isolation, high-frequency, power conversion transformers, etc.

Now the transformer has evolved to a new age. Our portable devices (Smartphones, tablets, laptops, etc.) are recharged by electronic transformers that we carry with us and use around the world, regardless of voltages and frequencies. In these small devices, magnetic induction has given way to solid-state electronics, and a similar evolution seems to be at the door in power applications, with the concept of solid-state transformers, which are expected to provide much more flexible operations, including energy storage and dc operation and connection.

The transformer plays a pivotal role in power transmission, which explains why it rules the electrical world ever since AC supply was introduced.

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Boston Dynamics

-SHUBHAM BHARDWAJ

Boston Dynamics is an engineering company that specializes in building dynamic robots and software for human simulation. The company began as a spin-off from the Massachusetts Institute of Technology, where National Academy of Engineering member Marc Raibert and his colleagues first developed robots that ran and maneuvered like animals. They founded the company in 1992, and their ground-breaking work continues to inspire several of the company's activities.

Today the company creates a variety of innovative robots, including BigDog, a quadruped robot for travel on rough-terrain, PETMAN, an anthropomorphic robot for testing equipment, RISE, a robot that climbs vertical surfaces, SquishBot, a shape-changing chemical robot that moves through tight space, and many others.

Boston Dynamics has an extraordinary technical team of engineers and scientists. The team seamlessly combines advanced analytical thinking with boots-in-the-mud practicality. We pride ourselves in building machines that are both innovative and actually work.

Changing Your Idea of What Robots Can Do

Boston Dynamics builds advanced robots with remarkable behavior: mobility, agility, dexterity and speed. We use sensor-based controls and computation to unlock the capabilities of complex mechanisms. Our world-class development teams take projects from initial concept to proof-of-principle prototyping to build-test-build engineering, to field testing and low-rate production.

Organizations worldwide, from DARPA, the US Army, Navy and Marine Corps to Sony Corporation turn to Boston Dynamics for advice and for help creating the most advanced robots on Earth.

The following pages give us an insight into the world of Google's Boston Dynamics. An introduction to the some marvels of engineering.

LS3 - Legged Squad Support Systems

LS3 is a rough-terrain robot designed to go anywhere Marines and Soldiers go on foot, helping carry their load. Each LS3 carries up to 400 lbs of gear and enough fuel for a 20-mile mission lasting 24 hours. LS3 automatically follows its leader using computer vision, so it does not need a dedicated driver. It also travels to designated locations using terrain sensing and GPS. LS3 began a 2-year field testing phase in 2012. LS3 is funded by DARPA and the US Marine Corps.

Boston Dynamics has assembled an extraordinary team to develop the LS3, including engineers and scientists from Boston Dynamics, Carnegie Mellon, the Jet Propulsion Laboratory, Bell Helicopter, AAI Corporation and Woodward HRT.

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Atlas - The Agile Anthropomorphic Robot

Atlas is a high mobility, humanoid robot designed to negotiate outdoor, rough terrain. Atlas can walk bipedally leaving the upper limbs free to lift, carry, and manipulate the environment. In extremely challenging terrain, Atlas is strong and coordinated enough to climb using hands and feet, to pick its way through congested spaces.

Articulated, sensate hands will enable Atlas to use tools designed for human use. Atlas includes 28 hydraulically-actuated degrees of freedom, two hands, arms, legs, feet and a torso.
An articulated sensor head includes stereo cameras and a laser range finder. Atlas is powered from an off-board, electric power supply via a flexible tether.
Several copies of the Atlas robot are being provided as Government Furnished Equipment for the DARPA Robotics Challenge program with delivery scheduled in the summer of 2013.

PETMAN

PETMAN is an anthropomorphic robot designed for testing chemical protection clothing. Natural agile movement is essential for PETMAN to simulate how a soldier stresses protective clothing under realistic conditions.

Unlike previous suit testers that had a limited repertoire of motion and had to be supported mechanically, PETMAN balances itself and moves freely; walking, bending and doing a variety of suit-stressing calisthenics during exposure to chemical warfare agents. PETMAN also simulates human physiology within the protective suit by controlling temperature, humidity and sweating, all to provide realistic test conditions.
The PETMAN system was delivered to the user's

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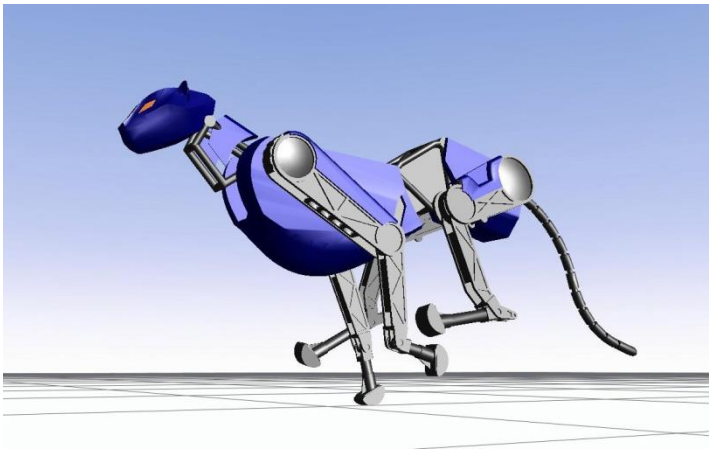
test facility where it is going through validation experiments. Boston Dynamics' partners for the program are MRIGlobal, Measurement Technologies Northwest, Smith Carter CUH2A (SCC), SRD, and HHI Corporation.

CHEETAH - Fastest Legged Robot

The Cheetah robot is the fastest legged robot in the World, surpassing 29 mph, a new land speed record for legged robots. The previous record was 13.1 mph, set in 1989 at MIT.

The Cheetah robot has an articulated back that flexes back and forth on each step, increasing its stride and running speed, much like the animal does. The current version of the Cheetah robot runs on a high-speed treadmill in the laboratory where it is powered by an off-board hydraulic pump and uses a boom-like device to keep it running in the center of the treadmill. The next generation Cheetah robot, WildCat, is designed to operate untethered. WildCat recently entered initial testing and is scheduled for outdoor field testing later in 2013.



Cheetah robot development is funded by DARPA's Maximum Mobility and Manipulation program.

BigDog – The Most Advanced Rough-Terrain Robot on Earth

BigDog is a rough-terrain robot that walks, runs, climbs and carries heavy loads. BigDog is powered by an engine that drives a hydraulic actuation system. BigDog has four legs that are articulated like an animal's, with compliant elements to absorb shock and recycle energy from one step to the next. BigDog is the size of a large dog or small mule; about 3 feet long, 2.5 feet tall and weighs 240 lbs.

BigDog's on-board computer controls locomotion, processes sensors and handles communications with the user. BigDog's control system keeps it balanced, manages

locomotion on a wide variety of terrains and does navigation. Sensors for locomotion include joint position, joint force, ground contact, ground load, a gyroscope, LIDAR and a stereo vision system. Other sensors focus on the internal state of BigDog, monitoring

the hydraulic pressure, oil temperature, engine functions, battery charge and others. BigDog runs at 4 mph, climbs slopes up to 35 degrees, walks across rubble, climbs muddy hiking trails, walks in snow and water, and carries 340 lb load.
Development of the original BigDog robot was funded by DARPA. Work to add a manipulator and do dynamic manipulation was funded by the Army Research Laboratory's RCTA program.

Big Dog

Sand Flea –
Leaps Small Buildings in a Single Bound

Sand Flea is an 11 pound robot that drives like an RC car on flat terrain, but can jump 30 ft into the air to overcome obstacles. That is high enough to jump over a compound wall, onto the roof of a house, up a set of stairs or into a second story window.

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The robot uses gyro stabilization to stay level during flight, to provide a clear view from the onboard camera, and to ensure a smooth landing. Sand Flea can jump about 25 times on one charge. Boston Dynamics is developing Sand Flea with funding from the US Army's Rapid Equipping Force (REF).

Earlier versions of Sand Flea were developed by Sandia National Laboratory with funding from DARPA and JIEDDO.

Sand Flea

RiSE: The Amazing Climbing Robot

RiSE is a robot that climbs vertical terrain such as walls, trees and fences. RiSE uses feet with micro-claws to climb on textured surfaces. RiSE changes posture to conform to the curvature of the climbing surface and its tail helps RiSE balance on steep ascents. RiSE is 0.25 m long, weighs 2 kg, and travels 0.3 m/s.

Each of RiSE's six legs is powered by a pair of electric motors. An onboard computer controls leg motion, manages communications, and services a variety of sensors, including joint position sensors, leg strain sensors and foot contact sensors.
Boston Dynamics developed RiSE in conjunction with researchers at University of Pennsylvania, Carnegie Mellon, UC Berkeley, Stanford, and Lewis and Clark University. RiSE was funded by DARPA.

innovate achieve lead

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A very thoughtful friend of mine once introduced me to Boston Dynamics. Dreams are what don't let you sleep. I dream to join Google's awesome Boston Dynamics, just like many of you. The search giant Google has undoubtedly established its supremacy in every aspect of technology and engineering. And Boston Dynamics today, undoubtedly controls the future of robotics. They say that robotics is the future of the human race. Does this signify that the big player may soon have a very direct role in our lives? Only time will tell! Amen!

Waste Plastics sorting using Near Infrared Spectroscopy

-Kalyan Pingali

Introduction

Background

Plastics are organic polymers made from synthetic or semi-synthetic materials that can be molded and reshaped under pressure or heat. Plastics because of its attractive properties like durability, low cost and ease of manufacture has found its application over range of products from bottles, packaging, carry-bags to special items like aerospace moldings and oil pipelines.

Most of the disposed plastics are incinerated or end up as landfills. Plastics because of its durability, offer resistance to natural degradation and degrade slowly. Disposing them in the open has adverse effects on environment. Degradation of plastics in landfills results in methane emissions, toxic sludge from plastic pollutants seep into soil & water and threaten the health and safety of humans & wildlife. Plastic debris in oceans is known to be the cause of deaths various marine animals and birds, either because they become entangled or mistake it for prey and eat it. Recycling of plastics is therefore vital.

Importance of Plastic sorting

Only a small percentage of the plastic that are disposed is recycled. This is so because plastics which are contaminated with other plastics are not reusable. Plastics are polymers made up of petrochemicals and there exist different types of plastic with different chemical substances. While recycling, plastics can be contaminated by the mixing of types and by non-plastic materials.

Segregating non-plastics, and different types of plastic like Poly Ethylene Teraphthalate (PET), High Density Poly Ethylene (HDPE), Poly Vinyl Chloride (PVC), Low Density Poly Ethylene (LDPE), Poly Styrene (PS) and Poly Propylene (PP) from each other are labor-intensive and hitherto, not many feasible techniques exist. Society of Plastic Industries (SPI) has standardized seven codes to identify different types of plastic for recycling. Widespread use of fillers and additives in plastics make them difficult to recycle because of the difficulty to remove fillers and additives from plastics. Additives are less widely used in PET (bottles, containers) & HDPE (milk jugs, shopping bags & shampoo bottle) when compared to other plastics. Due to the ease of recycling most of the recycled plastics is PET & HDPE. The need of the hour is affordable and efficient method that can sort different plastics quickly and accurately.

Near-InfraRed Spectroscopy and Multivariate analysis as potent tools for classification of plastics

Near-infrared spectroscopy (NIRS) is a spectroscopic method that uses the near-infrared

region of the electromagnetic spectrum (from about 780 nm to 2500 nm). NIRS is very useful in probing bulk material with little or no sample preparation. Due to the above

reasons NIRS has been widely applied in diverse fields from agricultural, petrochemical, pharmaceutical, clinical diagnostics, environmental and even characterization of plastics. Near-infrared spectroscopy is based on molecular overtone and combination vibrations caused by stretching and bending. The molecular overtone and combination bands seen in the NIR region are typically very broad and lead to complex spectra. Therefore, it can be difficult to assign specific features to specific chemical components. For this reason, multivariate calibration techniques are often employed to extract the desired chemical information. Examples of such methods include Spectral Angle mapping (SAM), Principal Components Analysis (PCA), Partial Least Squares (PLS), or Artificial Neural Networks (ANN). Careful selection of a set of samples representative of whole population and application of multivariate calibration techniques is essential for near-infrared analytical methods.

Near InfraRed Spectroscopy and Multivariate Analysis for Identification of Plastics

Near-infrared Spectroscopy

In the NIR region absorption bands correspond mainly to overtones and combinations of fundamental frequencies. The vibration of molecules can be described using the harmonic oscillator model, by which the energy E_{vib} of the different, equally spaced levels can be calculated from,

$$E_{vib} = (v + \frac{1}{2})\frac{h}{2\pi}\sqrt{\frac{k}{\mu}} \quad (1)$$

where, v is the vibrational quantum number, h is Planck's constant, k is force constant and u is reduced mass. Transitions take place between consecutive energy levels that cause change in the dipole moment. However, the harmonic oscillator model fails to explain behavior of actual molecules, as they don't account for Columbic repulsion between atoms or dissociation of bonds. As a result, they more closely represent anharmonic oscillations with unequally spaced energy levels, given as:

$$\Delta E_{vib} = hv[1-(2v+\Delta v+1)y] \quad (2)$$

Here y is the anharmonicity factor. The anharmonicity can result in transitions between vibrational energy. These transitions between non-contiguous vibrational states yield absorption bands known as overtones (first and second overtone, respectively) at, approximately, multiples of the fundamental vibrational frequency. Also, they are much less likely than the fundamental transitions, so the bands are much weaker (the band for the first overtone is 10–100 times weaker than that for the fundamental frequency, depending on the particular bond). These bands appear between 780 nm and 2000 nm, depending on the overtone order and the bond nature and strength. In polyatomic molecules, two or more vibrational modes can interact in such a way as to cause simultaneous energy changes and give rise to absorption bands called combination bands, the frequencies of which are the sums of multiples of each interacting frequency. NIR combination bands appear between

1900 nm and 2500 nm.
The intensity of NIR bands depends on the change in dipole moment and the an-harmonicity of the bond. Because the hydrogen atom is the lightest, and therefore exhibits the largest vibrations and the greatest deviations from harmonic behavior, the main bands

typically observed in the NIR region correspond to bonds containing this and other light atoms (namely C–H, N–H, O–H and S–H); by contrast, the bands or bonds such as C=O, C–C and C–Cl are much weaker or even absent

Why NIRS for plastic identification

NIR absorption or reflectance spectroscopy is very fast and well suited to analyzing transparent or lightly colored polymers. NIR spectra of common polymers found in the post-consumer and post-industrial waste stream are quite distinct. For this reason it is ideal for plastic identification and sorting. NIR spectroscopy offers many advantages for sorting waste plastics. It enables rapid reliable identification (within milliseconds) and is sufficiently robust to operate in dirty and vibration-prone industrial environments which are typical of sorting facilities.
The absorption of light in the NIR spectral range (14300 – 4000 cm^{-1}) is due to overtone or combination vibrations of polymer molecules. This can be an advantage since the reduced absorbance in the NIR allows the registration of spectra of bulky, high path length samples such as plastic bottles, which are of practical interest in many post-consumer-recycling processes. The C – H, O – H, N-H and S–H bands observed in NIR spectra can be characteristically attributed to specific polymers, thus enabling identification of most commonly used plastics. For example, the NIR spectra of HDPE exhibit a peak at around 1200 nm, which is, not present in PET and is only small for PVC. PET on the other hand exhibits three characteristic peaks in the region 1400 –1700 nm (refer Fig. 1).

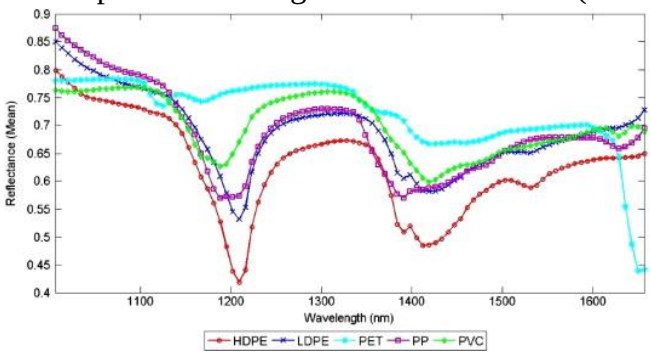


Fig.1: NIRS spectra of different plastic classes.

A further advantage of NIR is that the NIR photo detectors namely, germanium, indium arsenide, or indium gallium arsenide, have short response times and high detector sensitivities. Also, quartz fiber optics with low attenuation and low cost can be used for convenience and for remote sensing. NIR spectrometers typically have no moving parts and therefore they are not affected by the vibration or dust/dirt typical of plastic recovery facilities. Furthermore, NIR instruments require little maintenance and provide excellent reproducibility with negligible instrumental drift.

Multivariate Analysis as a vital cog in NIRS analysis

Multivariate Analysis (MVA) is the science of relating measurements made on a chemical system to the state of the system via application of mathematical or statistical methods and of designing optimal experiments for investigating chemical systems/ specimen. The goal of many MVA techniques is an efficient production of an empirical or semi-empirical model, derived for data, which is used to estimate one or more properties. Apart from obtaining a model that provides useful predictions, MVA techniques can also be used to obtain insight about a chemical system.

From NIRS to information on plastic class

While the NIRS contains valuable clues to the nature of the polymer, it has to be accompanied by MVA to unravel information. The data pretreatment and MVA methodology employed to evaluate the plastic polymers are listed below:

- Outlier detection: Outliers are aberrations in the data which occur due to errors in the instruments or in the acquisition of data. Outliers can significantly alter the characteristics of the data and hence have to be removed. In this work we employ Principal component analysis (PCA) to identify and remove the outliers.
- Baseline correction: Baseline correction is the process of removing background noise in the measurement of the data. In this work we have used the Savitzky Golay (11 point, 1st order differentiation) technique to correct the statistical noise in the spectral data.
- Scatter Correction: Scatter correction is necessary to offset any variations in the measurements due to differences in particle sizes (for powdery samples), effective path length and light scattering. In this effort we use the popular multiplicative-scatter correction (MSC) technique to correct for artifacts related to scattering.
- Pattern recognition, validation and analysis: To build the model and validate it we have applied the Successive Approximation Method (SAM).

Spectral Angle Mapping (SAM) for Pattern recognition

The spectral Angle Mapping is a simple algorithm for pattern correlation and recognition which does not involve complex statistical evaluation. It is commonly used for directly comparing a given spectra to a known spectra (usually determined in a lab or in the field with a spectrometer). This method uses all the features supplied to it to classify an unknown plastic polymer based on its NIRS spectrum. The spectral data (known as well as unknown) are considered as vectors in a multi-dimensional space and the angle between the vectors is used to determine their relative correlation. Taking dot product of the two spectrums does the projection and finding the angle between them.

Consider that two spectrum A and B, represented by vectors **a** and **b**, are under investigation. The two spectrum are compared by obtaining the angle of inclination between them using the formula,

$$\theta_{\mathrm{SAM}} = \cos^{-1}\left(\frac{a \bullet b}{\| a \| \, \| b \|}\right) \quad (3)$$

where, the operator stands for the dot product of the vectors and the operator || || connotes the Frobenius norm. The classification is based on finding the minimum or smallest angle between the unknown spectrum and the polymer class reference (library) spectrum. The cosine of the distance between these two vectors gives the correlation between their respective spectra. The above process is followed for all the available reference signatures. The reference signatures also include that of blank capture (i.e., without any material placed) to recheck for material availability.

Computational Hardware and Software

The MVA algorithms presented above were implemented in Python language and ported onto Raspberry Pi boards.

Raspberry Pi

Raspberry Pi is an open-source single-board microcontroller. The hardware consists of a simple open hardware design for the Raspberry Pi board and on-board input/output support. The software consists of a standard programming language compiler and the boot loader that runs on the board. Raspberry Pi hardware uses Linux kernel-based operating system.

Raspberry Pi can receive inputs from a variety of sensors and can control its environment by controlling Halogen lights, motors, Air nozzle and other actuators. The Raspberry Pi board is programmed using the Python programming language.

Python

Python is a general-purpose, high-level programming language and is famous for its code readability. Raspberry Pi extends excellent support to the Python language, some of the other merits of programming with Python in comparison to other mathematical tool/statistical packages such as MATLAB™ or R language. Python has a separate GPIO module which allows us to access GPIO pins on Raspberry Pi. Python supports multiple programming models, including object-oriented, imperative and functional programming styles. Python is a scripting language, but can also be used for non-scripting.

Interfacing the embedded hardware and NIRS instrument

Serial communication is used for communicating between Raspberry Pi boards and the NIR Spectrometer. Serial communication is the process of sending data one bit at a time, sequentially, over a communication channel or computer bus. An RS232 serial port operates at ±12V and can damage the Raspberry Pi board if connected directly to the pins of the Raspberry Pi. Hence, we use a RS-232 to USB converter that would directly go into the USB port of the Pi to interface the NIR spectrometer and the embedded system.

Technical Description of the System

Components of the System

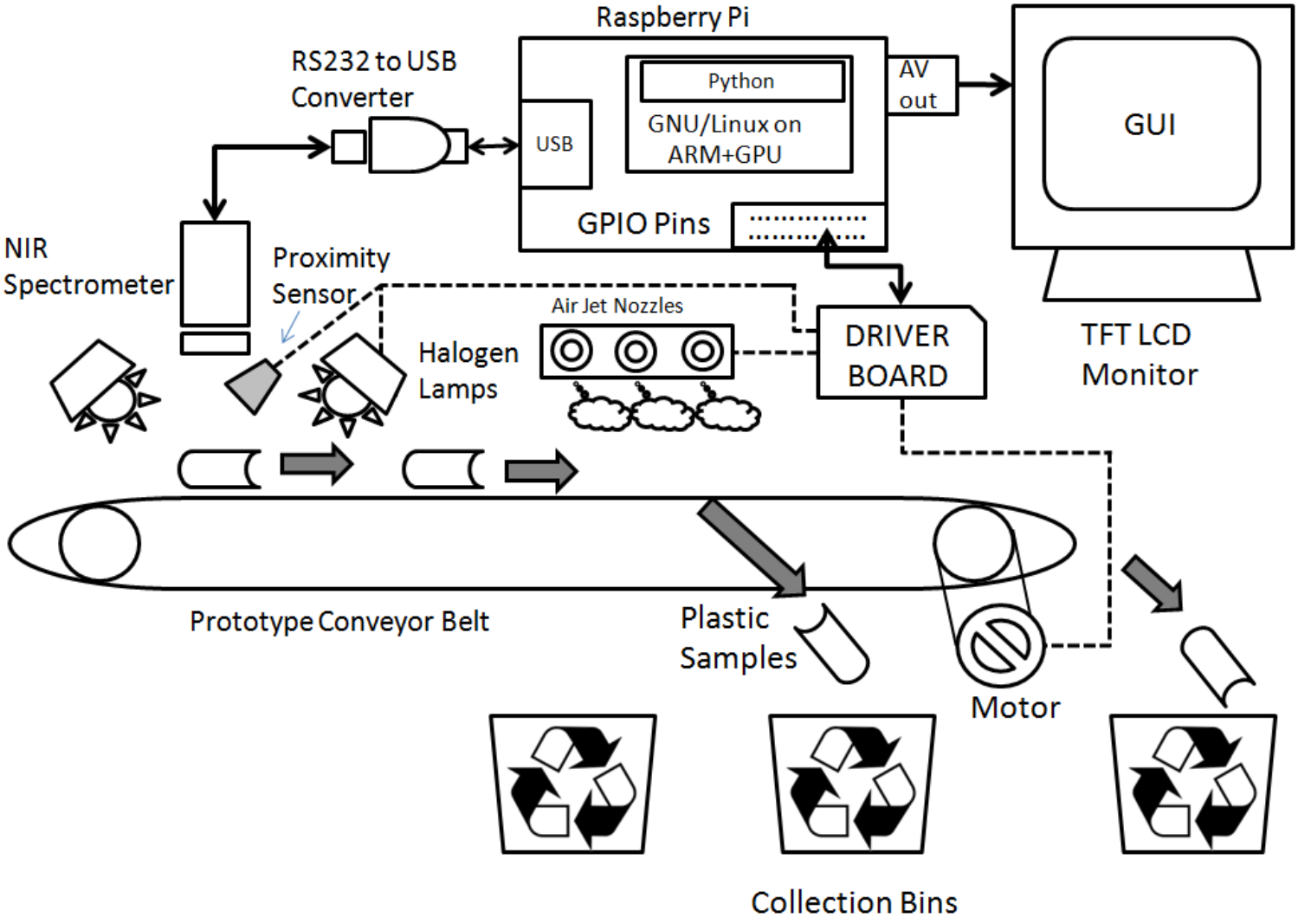
The schematic diagram of the plastic sorter is shown in Fig. 2. The system consists of the following units:

- a conveyor belt assembly for on-line capture of spectral signature of plastic materials that are to be sorted,
- a white light source (halogen lamp) with wide spectral response,
- an optical assembly to collect rays reflected by the plastic material,
- a NIR based Diode Array Spectrometer (DAS) which interprets the optical information and converts into digital data,
- proximity sensor
- an embedded system to collect digital data from the spectrometer and perform necessary mathematical computations to identify nature of polymer,
- an Air-Jet nozzle which is used to segregate the material of choice.

System Operation

The process flow diagram is depicted in Fig. 3. The operation of the system is briefly explained below:

1. The singulated consumer/domestic waste polymer samples move on a fixed speed conveyor.
2. The samples are irradiated by ordinary lamps of 250 watts.
3. Optical device senses the vicinity of samples and initiates the DAS to capture the signal.
4. The optical assembly collects the reflectance light and through a multi-mode optical fiber communicates it to the DAS.
5. The embedded system collects the spectrometer data performs baseline correction, scatter correction and pattern recognition of the signature of the polymer and uses decision supporting system for classification.
6. Jet Nozzles are activated based on the command signal to eject classified plastics into their respective bins.
7. The data base is updated for all the classified consumer polymers



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DID YOU KNOW?

- A bolt of lightning can measure up to three million (3,000,000) volts and it lasts less than one second!
- Thomas Edison didn't invent the first light bulb but he did invent one that stayed lit for more than a few seconds. Thomas Edison invented more than 2,000 new products, including almost everything needed for us to use electricity in our homes: switches, fuses, sockets and meters.
- Ben Franklin didn't discover electricity but he did prove that lightning is a form of electrical energy.
- According to the U.S. Energy Information Administration, electricity consumption will increase by 51 percent from 2002 to 2025.
- The first power plant owned by Thomas Edison opened in New York City in 1882.
- The first central power plant? Pearl Street Station in lower Manhattan, built by Thomas Edison began generating electricity on September 4, 1882. Pearl Street had one generator and it produced power for 800 electric light bulbs. Within 14 months, Pearl Street Station had 508 subscribers and 12,732 bulbs. Since the first power plant lit up 800 light bulbs in 1882, the electric utility industry has grown to generate over 2.5 million gigawatt-hours annually, the equivalent of lighting 4.8 billion 60-watt light bulbs for a year.
- If you scuffed your feet long enough without touching anything, you would build up so many electrons that your finger would explode! But this is nothing to worry about, unless you have carpeting.
- The electrons travel through your bloodstream and collect in your finger, where they form a spark that leaps to your friend's filling, then travels down to his feet and back into the carpet, thus completing the circuit.
- In the past decade scientists developed the laser, an electronic appliance that emits a beam of light so powerful that it can vaporize a bulldozer 2,000 yards away, yet so precise that doctors can use it to perform delicate operations on the human eyeball, provided they remember to change the power setting from "VAPORIZE BULLDOZER" to "DELICATE."
- If you had a light bulb on the moon connected to a switch in your bedroom, it would take only 1.26 seconds for that bulb to light up, 238,857 miles away.
- If you travelled as fast as electricity, (about 300,000 kilometres = 186,411.358 miles per second the speed of light), you could go around the world 8 times in the time it takes to turn on a light switch.

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