ECS RESEARCH DAY 2019

FACULTY PRESENTATIONS

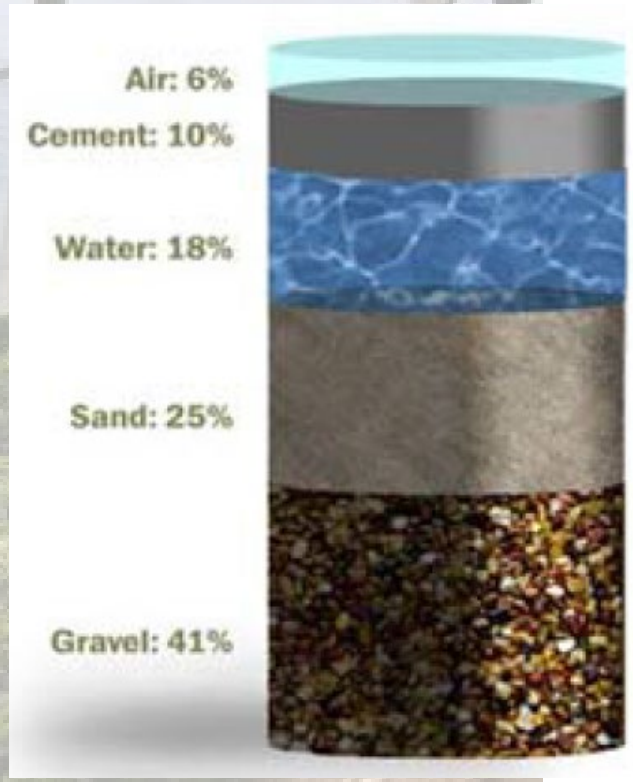
Concrete Materials Infrastructure Lab

Dr. Pratanu Ghosh

Associate Professor

Civil and Environmental Engineering Department

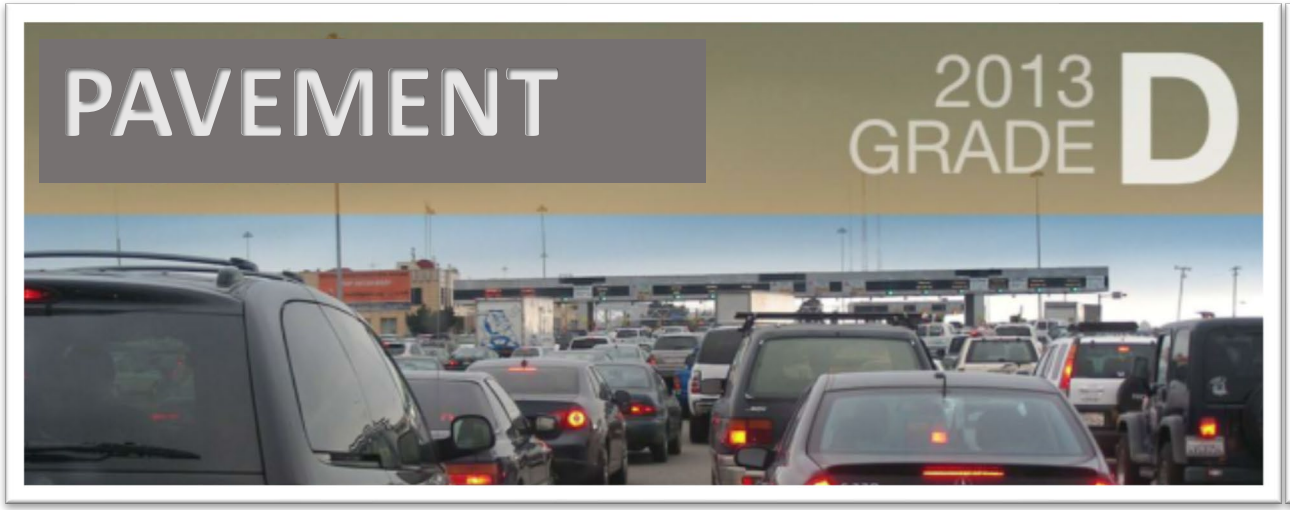
Smart Concrete for Smart Bridges

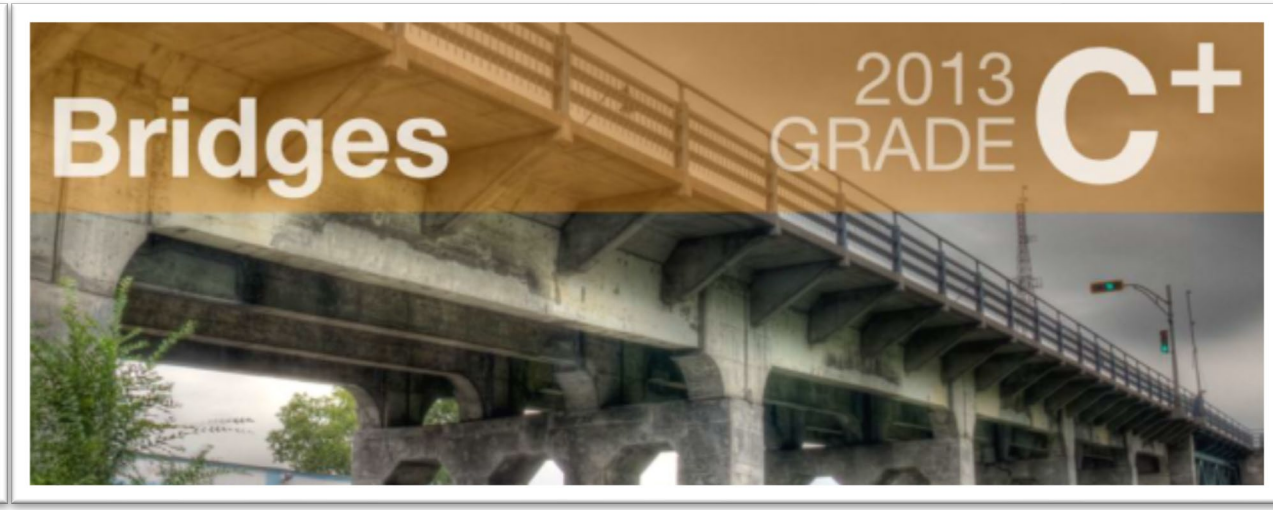


ONE OF THE MOST THREATENING ISSUES TO NATION'S INFRASTRUCTURES

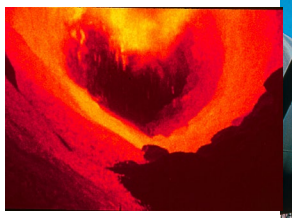
Current Condition

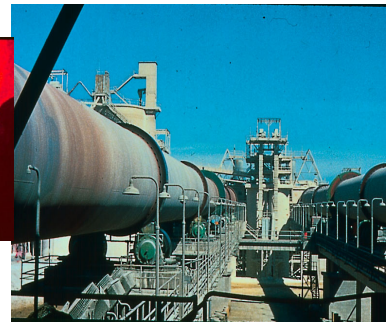
- Health condition of roads and bridges in the USA (American Society of Civil Engineers - ASCE report)





Grading scale:
A – Exceptional (Fit for the future)
B – Good (Adequate for now)
C – Mediocre (requires attention)
D – Poor (At risk)
F – Failing/ Critical (Unfit for purpose)





CHLORIDE INDUCED CORROSION

COLLAPSE

INCREASE IN SEA LEVEL

+ CO_2 EMISSIONS

How to reduce CO_2 emissions in concrete industry?

How to Save Money

How to STOP these disasters

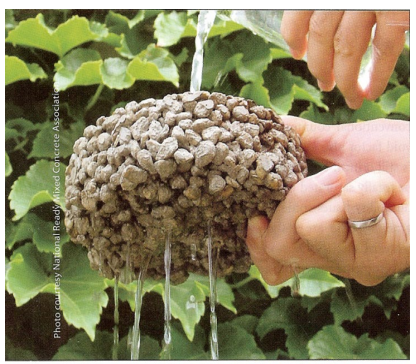
This is What We Did!

Partially Replaced Cement with

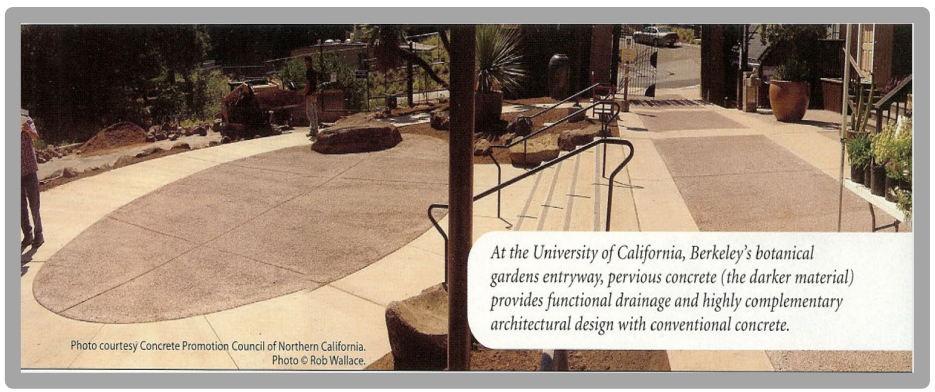
Prevents Corrosion

Cheap and Easily available

Environmental Friendly



By allowing moisture to filter through into groundwater, the Rice Krispie-like structure of pervious concrete helps reduce the environmental problems of stormwater runoff.



Pervious Concrete

NEW ADVANCED SMART SENSING INSTRUMENTS

Emerging NDT instrument

NEW CUTTING-EDGE NON DESTRUCTIVE INSTRUMENTS

Fresh Electrical Resistivity using RCON tester

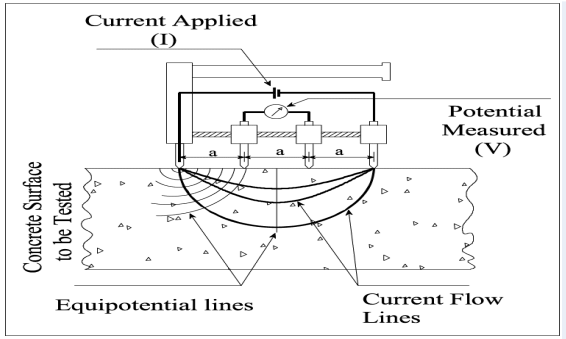
Non-Destructive

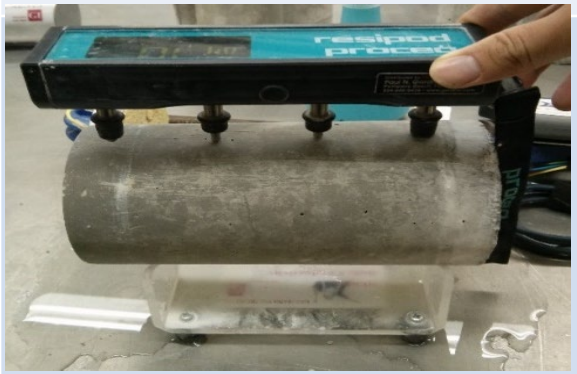
Readings are taken every 10 seconds for a period of 7 hours

Moisture Meter

Checks the temperature and humidity variation

4-point Wenner Probe

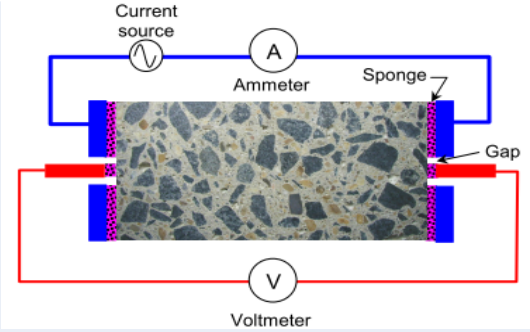




8 readings are taken two times (0, 90, 180, 270°)

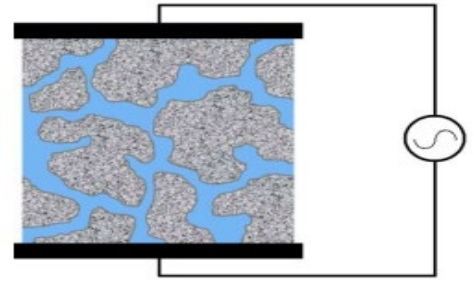
Merlin meter

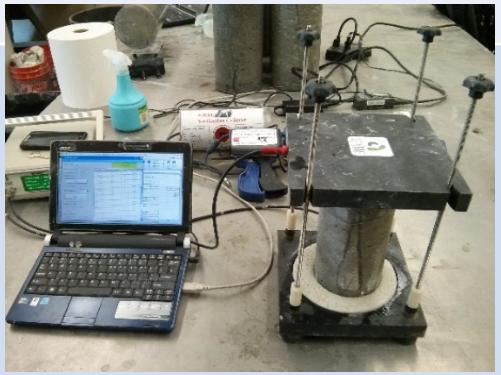
Non-destructive test



2 readings are taken by swapping 2 endings of the specimens

RCON tester





Testing time is **less than 3 minutes per sample**

Non-destructive Concrete maturity

Indirect way of measurement of in-situ strength of concrete

Purpose of this Study

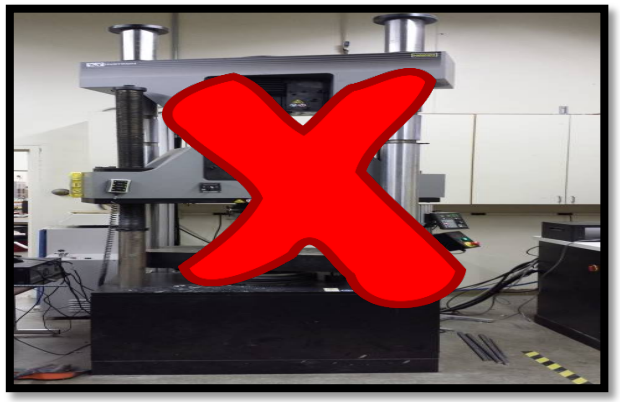
To investigate,

- the maturity of each HPC mixture
- the equivalent age of HPC mixture

Is there any way to find the Maturity without using Compressive strength?

YES, There is a way!

Compressive strength test



Maturity method

Form work Removal

Each of the five graduate students who were awarded the DDETFP award will receive $5,500. Awardees can then use those funds as they see fit. (Yunuen Bonaparte/Daily Titan)

Conclusions

- The novel use of binary and ternary HPC mixtures yields,
  - High strength
  - Durability
  - Money saver
  - Eco-friendly

- Health monitoring of reinforced concrete structures can be performed accurately and quickly
- The non-destructive testing instruments provide many advantages:
  - Time Saver
  - Easy setup and testing procedure
  - Provides accurate data
  - Portable
  - Can be used in actual construction site.

- This research benefits the DOT's and Engineers by
  - Saving money and time

Recent Publications:

1. **Ghosh, P.** and Ganesan, R*. "Influence of Various SCMs on Fresh Electrical Resistivity and Computation of Setting Time", *Proceedings at Transportation Research Board 99th Annual Meeting*, 2020.
2. Modha, N.* and **Ghosh, P.** "Zeolite-Based New Generation Concrete-Sustainable and Durable Solution for Nations Infrastructure", *ACI Special Publication for ACI 130 and 224-Cracking and Durability in Sustainable Concrete*, 2019.
3. Lehner, P.,* **Ghosh, P.** and Konecny, P. "Statistical Analysis of Time Dependent Variation of Diffusion Coefficient for Various Binary and Ternary Based Concrete Mixtures", *Construction and Building Materials,* Vol, 183, pp. 75-87, 2018.
4. Tran, Q*, **Ghosh, P.**, Konecny, P. and Lehner, P. " Variation of Diffusion Coefficient for Selected Binary and Ternary Concrete Mixtures Considering Concrete Aging Effect, *Journal of Key Engineering Materials,* Vol. 761, pp. 144-147, 2018.
5. **Ghosh, P.**, Konecny, P., Lehner, P.*, and Tikalsky, P. "Probabilistic time-dependent sensitivity analysis of HPC bridge deck" *Journal of Computers and Concrete,* Vol. 19, No. 3, pp. 305- 313, 2017.
6. Tran, Q.*, **Ghosh, P.**, Lehner, P. and Konecny, P. "Determination of Time Dependent Diffusion Coefficient Aging Factor of HPC Mixtures", *Accepted for publication in Journal of Key Engineering Materials* in 2020.
7. Modha, N.* and **Ghosh, P.** "Zeolite-Based New Generation Concrete-Sustainable and Durable Solution for Nations Infrastructure", Proceedings at ACI Fall Convention, 2017.
8. Tran, Q*, **Ghosh, P.**, Konecny, P. and Lehner, P. "Computation of Diffusion Coefficient and Its Aging Factor for Different Binary and Ternary Based Concrete Mixtures", *Proceedings at Transportation Research Board 96th Annual Meeting*, 2017.

Thank you

MITSUBISHI CEMENT CORPORATION

BASF We create chemistry

Vulcan Materials Company

CMT

HW HEADWATERS

LEHIGH HEIDELBERGCEMENT Group

CALPORTLAND

Hess PUMICE

Why is There a Need to Implement Evidence-Based STEM Teaching?

Yong Seok Park

Assistant Professor, Department of Mechanical Engineering

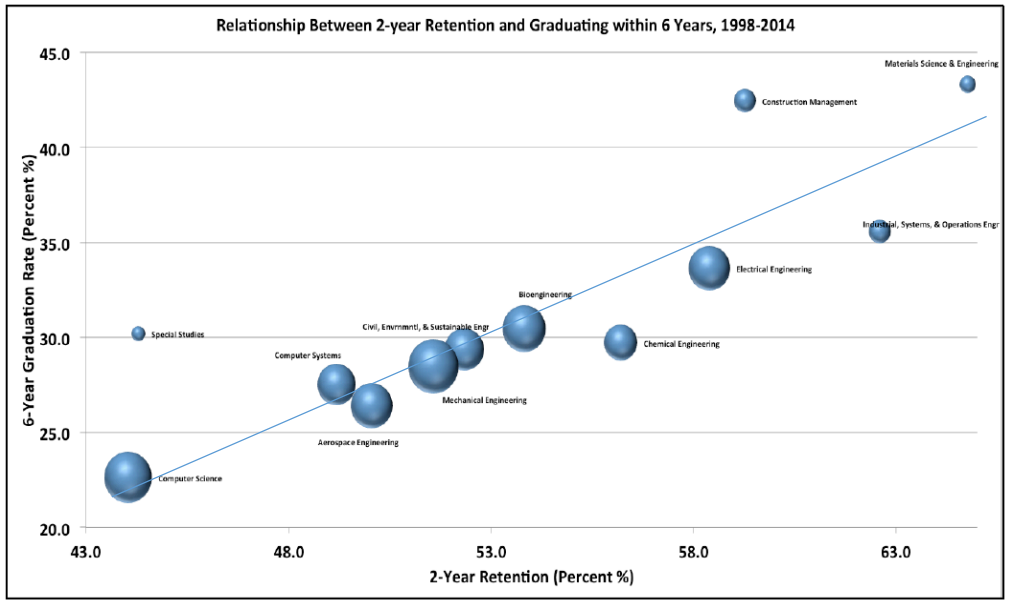
College of Engineering & Computer Science, California State University, Fullerton

800 N State College Blvd., E-315, Fullerton, CA 92834

Why is There a Need to Implement Evidence-Based STEM Teaching? Engineering 2-Year Persistence and 4-Year & 6-Year Graduation Rates

ASU data

	First Time Freshman	2-Year Persistence Rate	4-Year Graduation Rate	6-Year Graduation Rate
1998	644	45%	11%	34%
2004	765	50%	18%	38%
2007	720	50%	26%	42%
2009	890	57%	32%	NA
2011	1197	58%	NA	NA
2014	2450	NA	NA	NA



Conclusions 1: Strong need for increase in evidence-based teaching in Years 1 and 2

Focus faculty development on instructors in Year 1 & 2 courses

Effectiveness of innovations may begin to be assessed after 2 years

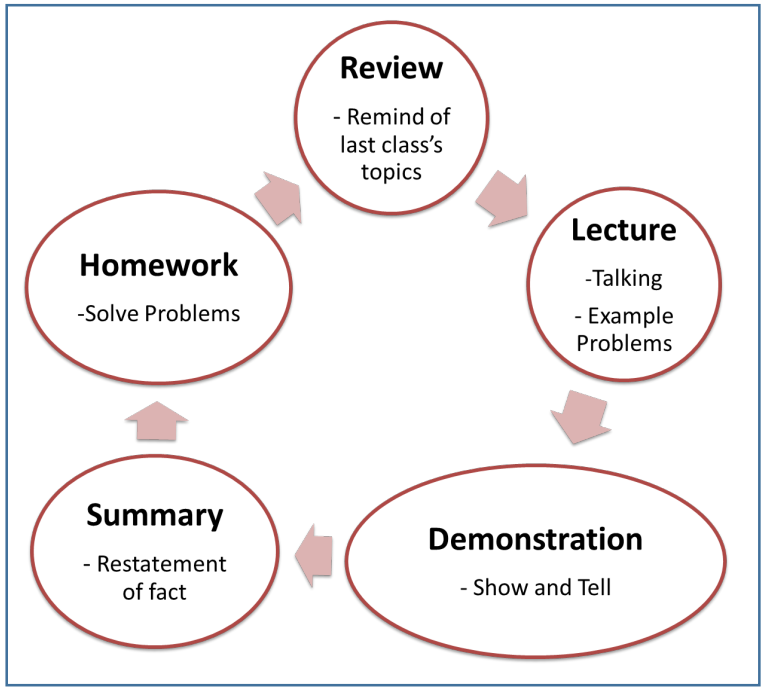
Conclusions 2: 2-year persistence is a good predictor of 6-year graduation rate

Significant differences exist between disciplines in persistence & graduation

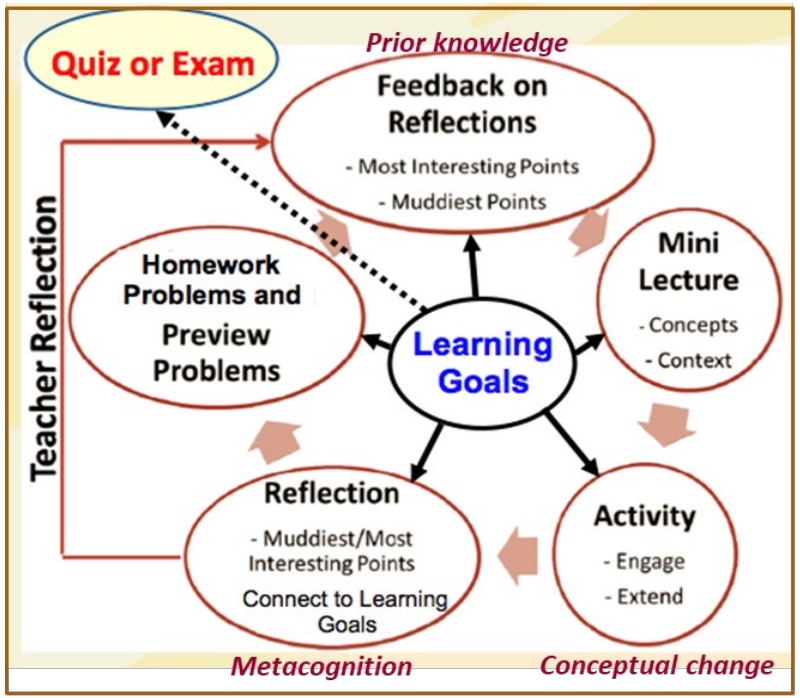
How Does JTF Pedagogy Help Shift Classroom Culture?

JTF: Just-in-Time-Teaching with Interactive Frequent Formative Feedback
JTF is a web-enabled, engagement and feedback pedagogy

Instructor-Centered Teaching



JTF Student-Centered Learning



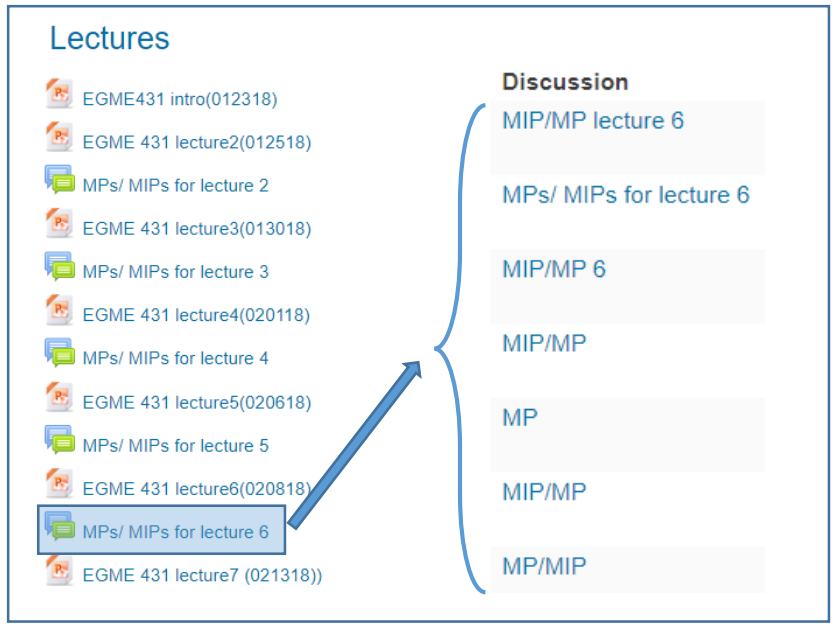
What Does Implementation of Muddiest Point Feedback Look Like?

Learning Goals for Class

Students will be able to

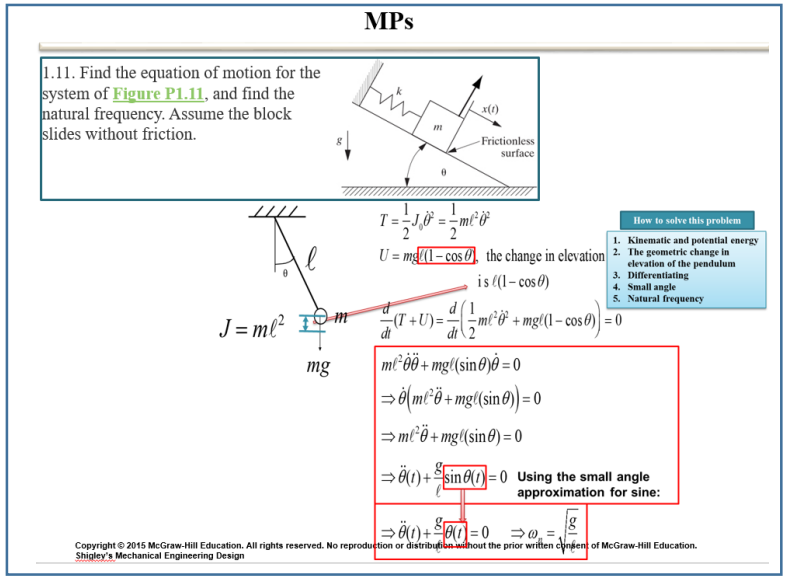
- **Understand spring mass damper system with applied force and determine solution for the system**
- **Understand difference between natural frequency and driving (forcing) frequency in applied force**
- **Understand what the system response looks like when natural frequency and driving (forcing) frequency in applied force**

Muddiest point responses copied from Titanium



EGME 431
(Mechanical Vibrations)

Next class instructor feedback aligns issues w/ learning goals

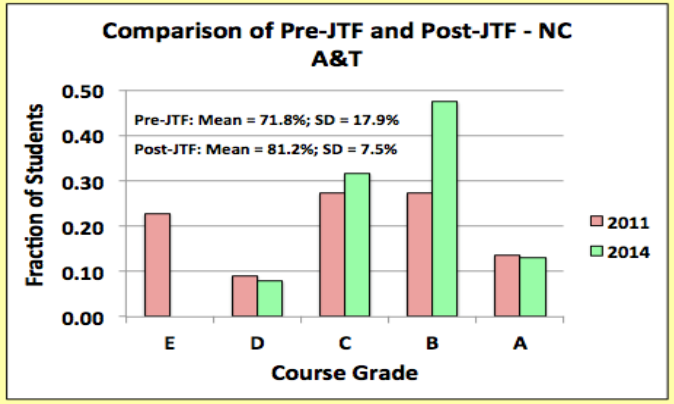


Muddy point quotes selected by instructor

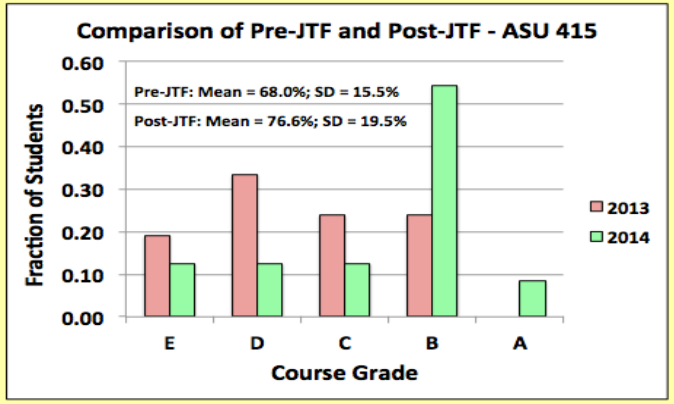
- how come we don't use height potential energy in problem 1.11 but we use height potential energy in the exam example
- the muddiest point was the in class example with the two springs attached to a pendulum.
- MP: Utilizing the lagrange to solve rotational motion problems
- The muddiest point of lecture was why we do not use gravity or mass on the inclined mass-spring problem.

JTF Engagement Pedagogy - Achievement in 4 Classes at 3 Institutions

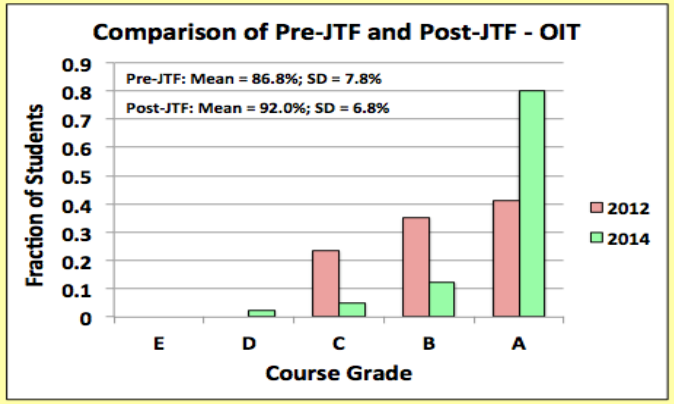
Cindy Waters; North Carolina A&T – Intro Materials



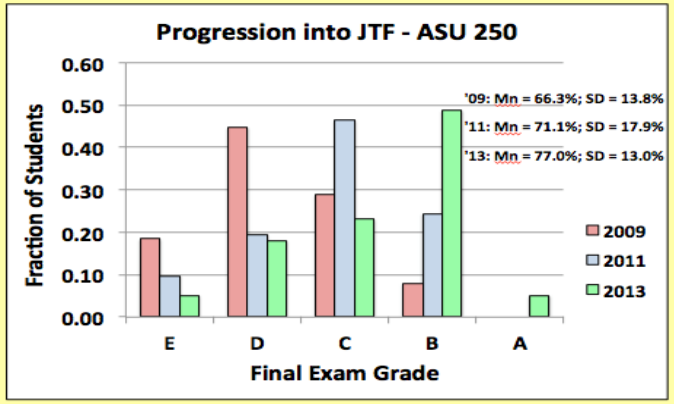
Shariar Anwar; Arizona State – Math. Methods Materials



Joe Stuart; Oregon Institute of Technology – Intro Materials



Stephen Krause; Arizona State – Intro Materials



- **Overall: In 4 classes JTF increased medians by a half to full grade & decreased Ds & Es >50%**

ASU data

Improved Persistence from JTF Engagement Pedagogy

- **Student Persistence (2nd week – final) in JTF Project; 5 classes & 4 institutions**
- **Fall 2013 - 97% (227 / 235)**
- **Spring 2014 - 95% (311 / 328)**

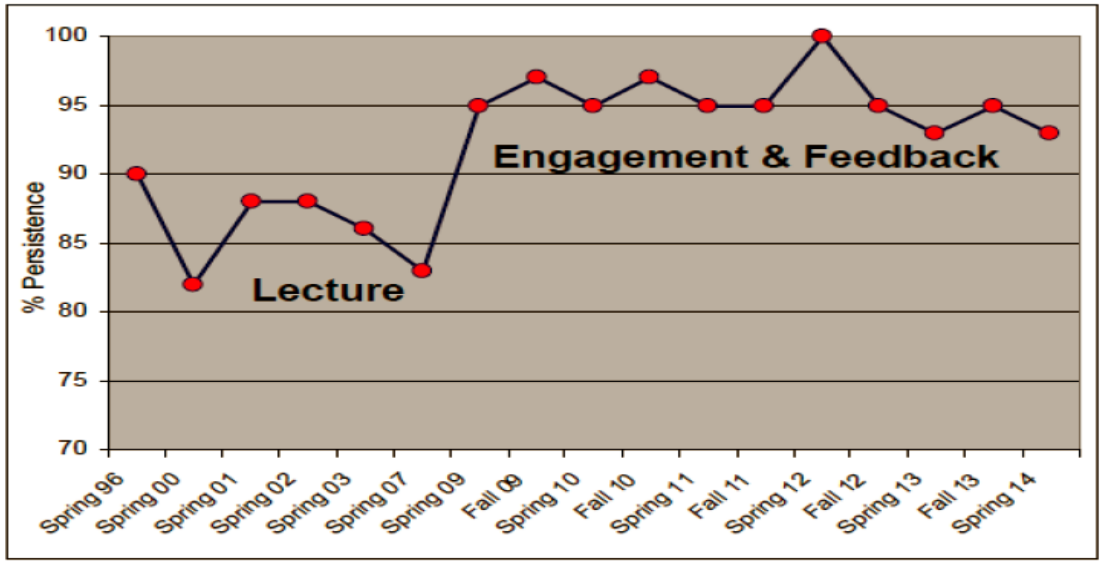


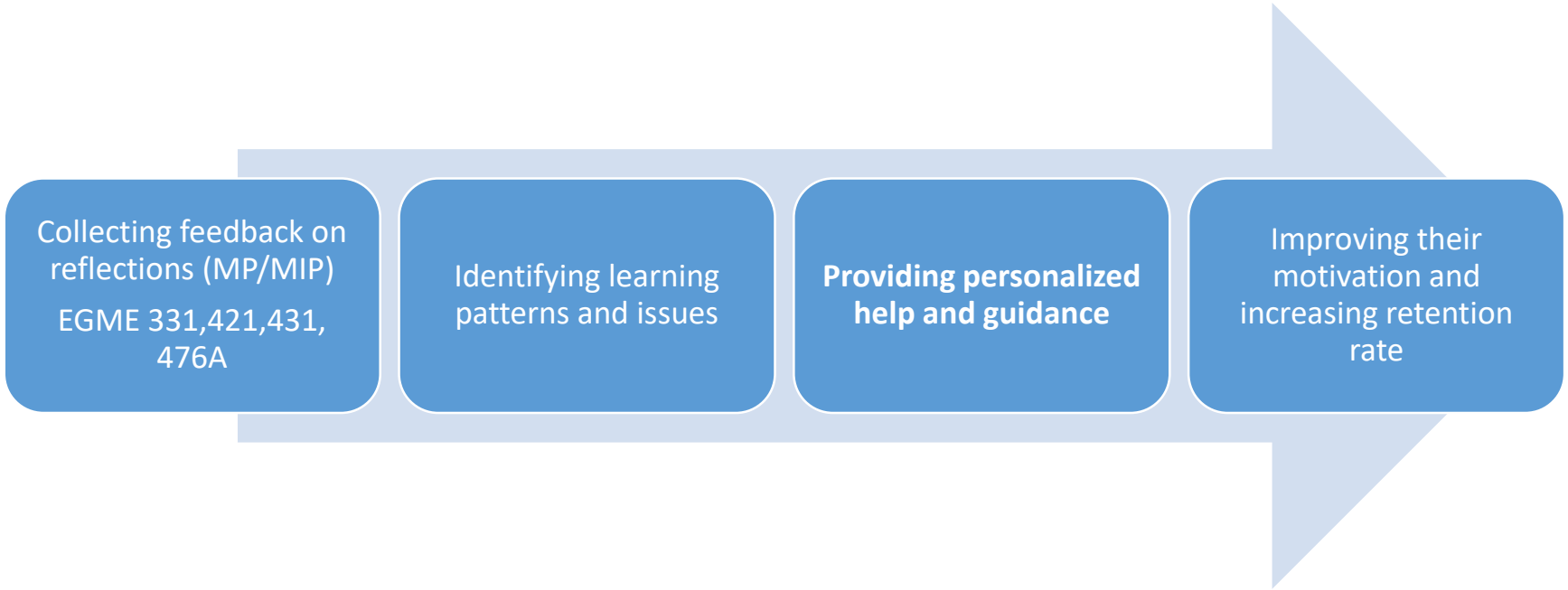
Figure 1. Persistence over time for lecture versus engagement pedagogy in a materials course.

Student Persistence in Introductory Materials Class (n=35-55)

- ***Overall: Persistence increased significantly with JTF pedagogy***

Conclusion and Future Work

- **Faculty shifted beliefs and adopted JTF pedagogy in classroom practice**
- **Faculty assumed ownership of JTF innovations in a community of practice**
- **These factors enhanced student attitude, achievement, and persistence**



ANKITA MOHAPATRA

“ELECTRIC STIMULUS-RESPONSIVE CHITOSAN/MNP COMPOSITE MICROBEADS FOR A DRUG DELIVERY SYSTEM”

JIDONG HUANG

“NAVIGATION: AN INTERDISCIPLINARY AREA OF RESEARCH”

The State of Artificial Intelligence (A.I.)

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College of Engineering and Computer Science
California State University, Fullerton
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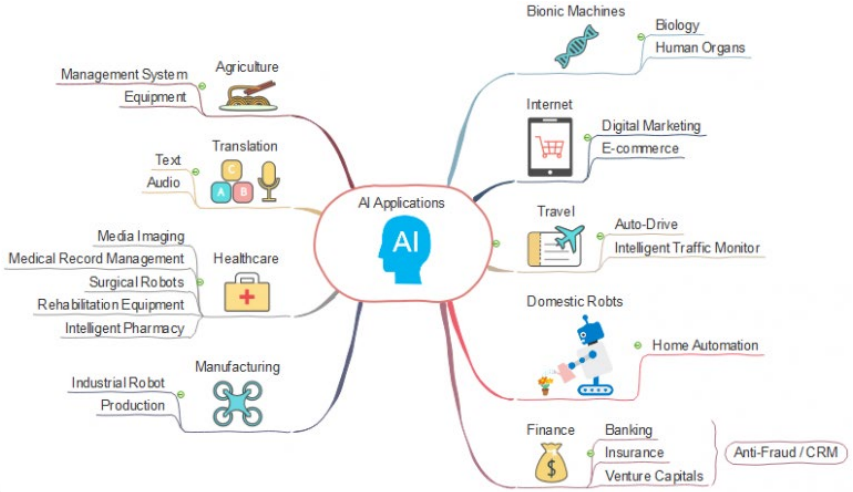
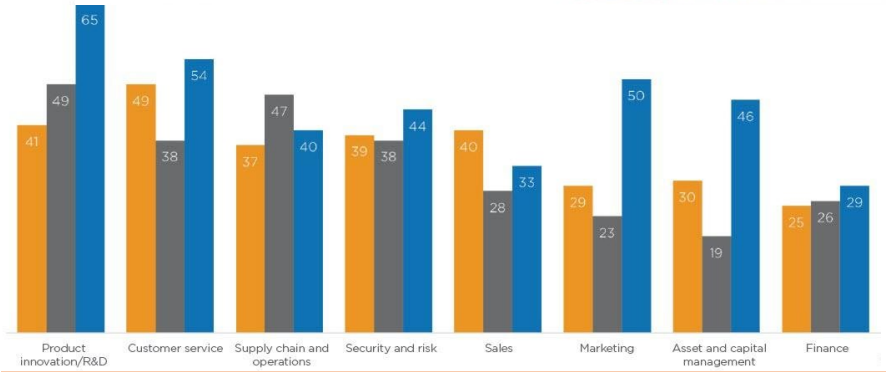
A.I. Research Status

A.I. applications

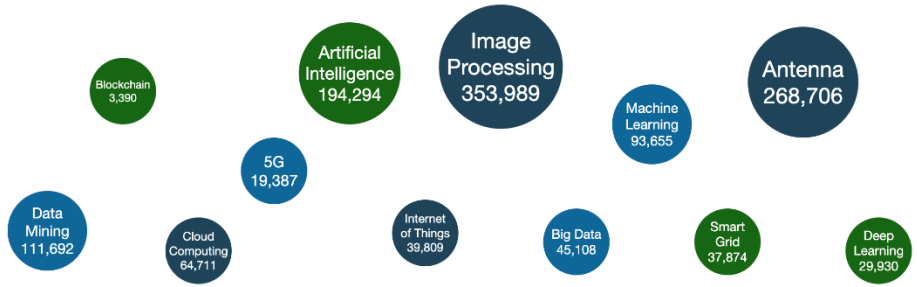




80% of enterprises are investing in A.I. today

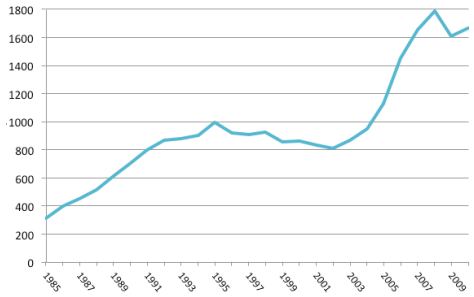
NSF funding for A.I.

Fiscal Year	IIS (Information and Intelligent Systems) Funding In Millions of $	Total CISE (Computer and Information Science and Engineering Funding in Millions of $	IIS Funding as a % of total CISE Funding
2017 (Requested)	207.20	994.80	20.8
2016 (Estimate)	194.90	935.82	20.8
2015 (Actual)	194.58	932.98	20.9
2014 (Actual)	184.87	892.60	20.7
2013 (Actual)	176.23	858.13	20.5
2012 (Actual)	176.58	937.16	18.8
2011 (Actual)	169.14	636.06	26.5
2010 (Actual)	163.21	618.71	26.4
2009 (Actual)	150.93	574.50	26.3

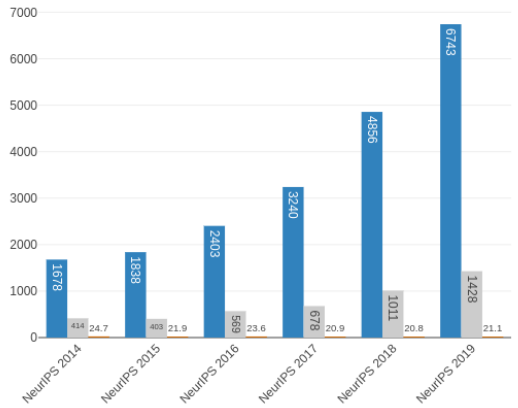


Top searches in IEEE Xplore

A.I. Research Market



Ph.D. students in A.I. increased



Top conference acceptance rate decreased

NIPS 2018
Sun Dec 2nd through Sat the 8th, 2018 at Palais des Congrès de Montréal

Paper ID: 29
Title: Efficient Algorithms for Non-convex Isotonic Regression through Submodular Optimization

Reviewer 1

This paper studies continuous submodular minimization under ordering constraints. The main motivation is to extend the settings in which efficient algorithms for isotonic regression exist. In particular, they extend such settings from convex objectives to submodular objectives. First, the authors show that this problem can be reformulated as a convex optimization problem with isotonic constraints. Since this convex problem is in a space of measures, it cannot be optimized exactly. Instead, the authors propose a discretization approach as in Bach18. The discretization approach is improved from the naive 1/eps^3 evaluations to 1/eps^2.33. Finally, the authors experimentally consider robustness to outliers with their approach. Examples of continuous submodular functions are listed, as well as a separate motivation for isotonic constraints, but it would have been nice if a concrete application of the problem studied was explained in detail. On the theoretical side, I don't find the improvement from a naive 1/eps^3 number of evaluations to 1/eps^2.33 to be of major significance. I also found the paper to be very dense and often hard to follow sometimes. An example is that it is not clear how the noise and corruptions fit in the model. It would have been nice to have additional discussions about what corrupted data corresponds to in this setting.

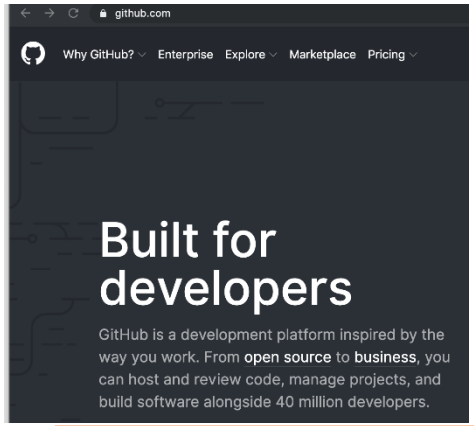
Reviewer 2

In this paper the authors consider the problem of minimizing a continuous submodular function subject to ordering (isotonic) constraints. They first show that the problem can be solved if we first discretize it (per coordinate, not in $[0,1]^n$), and then solve the resulting discrete optimization problem using convex optimization. The fact that the problem is solvable in polynomial time is of course not surprising, because, as pointed out by the authors in lines 29-36, we can add a penalty to the objective that will implicitly enforce the constraints. However, this can significantly increase the Lipschitz constant of the objective, and that is why the authors take on an alternative approach. First, they prove that seen in the space of measures, the isotonic constraints correspond to dominating inequalities of the CDFs, which I guess is an intuitive result given the results known for the unconstrained case. For the discrete problems this adds another set of inequality constraints that have to be satisfied. Projection onto these constraints can be done using parametric maxflow among other techniques, so that the authors are able to achieve rates for this problem similar to those for the unconstrained one (sections 4.2 and 4.3). How this is exactly done is not clear, and I would suggest the authors to perhaps show how they reduce their problem to say parametric maxflow in 4.4, or at least in the supplementary. The authors later go on to discuss improved discretization algorithms. I would like to point out that all these schemes are uniform, in the sense that the points are equally spaced. What the authors analyze is the number of points that you need under different smoothness assumptions. Under uniform bounds on the gradients, they construct a surrogate for the function that is submodular and whose minimization results in faster rates. However, it is hard to evaluate as it requires the minimization of polynomials over box constraints - hence, I think of this algorithm to be of a more theoretical nature. Furthermore, the given guarantees, if I'm not mistaken, assume an exact evaluation of the surrogate. It is not clear if we instead solve approximate methods (e.g. SDP relaxations). Finally, I would like to remark that I did not read the proofs of the numerous convergence rates provided in the paper. Questions / Comments ---- 1. You project onto the constraints using parametric maxflow by solving a graph-cut problem with very large weights corresponding to E? How do you incorporate the box [0, 1] constraints? 2. Don't orthogonal projections and separable problems (section 4.4) reduce to the same problem? Can't you use one parametric flow also for the separable problems? If yes, I would suggest to present these together. 3. What is the purpose of section 5.2? I can not see how it is related to the discretization strategies. 4. l286 - Why only chain constraints? It is not clear from the Section 4.2, as there you add one constraint for each edge in E. 5. In \Delta H in Fig.3. the difference of the computed optimum between two consecutive discretizations? Post-rebuttal: The rebuttal addressed all of my questions and comments. However, the more fundamental issues with the method that I have outlined (surrogate hard to evaluate, no guarantee under approximate surrogate evaluation) seem to hold, and that is why I will keep my score.

Reviewer 3

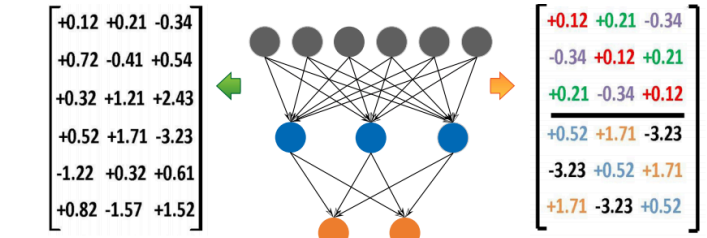
This paper studies continuous submodular minimization subject to ordering constraints. The main motivation is isotonic regression with a separable, nonconvex loss function. The starting point is the relationship between submodular minimization and convex minimization over a space of measures. It is demonstrated that ordering constraints correspond to stochastic dominance, and algorithms are proposed to enforce these constraints during optimization. The starting point is a simple way of discretizing the CDF corresponding to each variable. Then, improved discretization schemes are presented, depending on the availability of higher-order derivatives. Experimental results show that using a nonconvex loss function can improve robustness to corrupted data in isotonic regression. This paper is well-written, and makes a good set of technical contributions in showing how to incorporate ordering constraints and improve the discretization schemes. The experimental results nicely show the conditions under which the new techniques improve over standard methods. A couple questions: 1) Is there some intuition for why nonconvex losses like the proposed logarithmic function are more robust to outliers than squared or absolute value loss? 2) It makes sense that higher-order derivatives would improve the convergence rate in terms of number of iterations. However, this requires additional computation to get the Hessian (or even higher-order terms). Is the tradeoff worth it in terms of actual runtime?

Publish Reviewer Comments



Open code and papers

My approach: An unique theory in an unique application



Unstructured Weight Matrix (18 parameters)

Block-Circulant Weight Matrix (6 parameters)

Figure 1: Block-circulant Matrices for weight representation.

Motivation

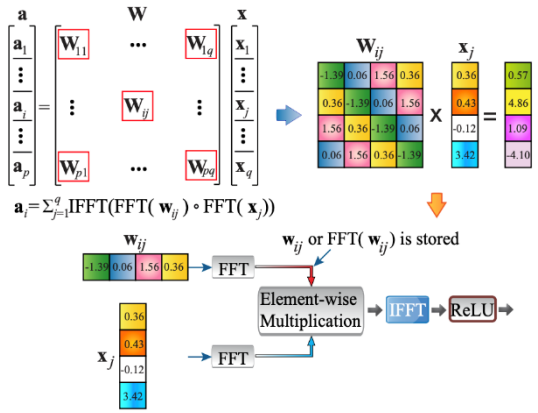


Figure 5: Illustration of the calculation of Wx in the inference process of FC layer.

Approaches

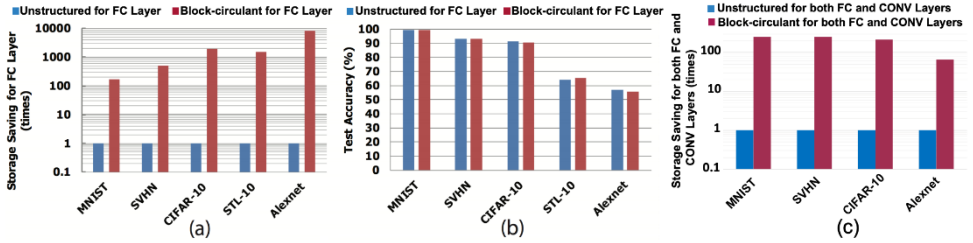


Figure 7: (a) Storage saving and (b) test accuracy after using block-circulant FC layer for DCNN models on different datasets. (c) Storage saving after using both block-circulant FC layer and block-circulant CONV layer for DCNNs on MNIST, SVHN, CIFAR-10, and ImageNet datasets.

Storage Saving of the proposed work

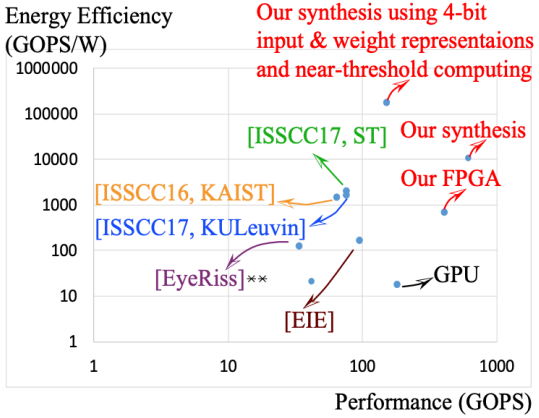


Figure 15: Comparison on performance and energy efficiency with state-of-the-art ASIC results.

Comparison on performances

Energy Conservation for IoT Sensors

Anand Panangadan

apanangadan@fullerton.edu

ECS Research Day

December 5, 2019

Internet-of-Things (IoT)

- IoT: using the Internet to enable physical devices to collect and share data autonomously
- Promise of IoT
  - Provide real-time, continuous monitoring of our environment

Example: Smart restrooms

Found in Heathrow's Terminal 2, these "smart" loos have embedded sensors that track people's movement and bathroom flow, and can alert maintenance crews if there's a problem

Driving Forces of IoT

1. Sensor Technology – Tiny, Cheap, Variety
2. Cheap Miniature Computers
3. Low Power Connectivity
4. Capable Mobile Devices
5. Cloud computing

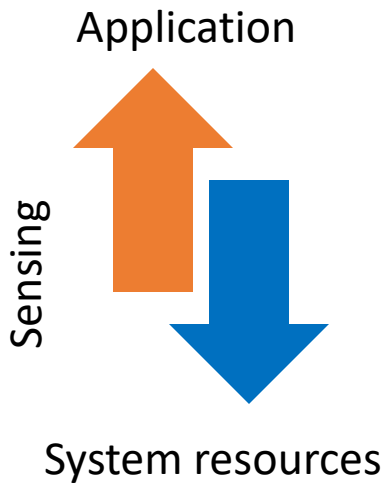
Trend: make it small

Need for resource management

- Mobile monitoring limits size and weight, and hence energy capacity of sensor nodes is limited
- Wireless communication is energy intensive
- Energy required to operate electro-mechanical components in biosensors/actuators
- Guaranteeing system lifetime is critical for many applications
  - Medical

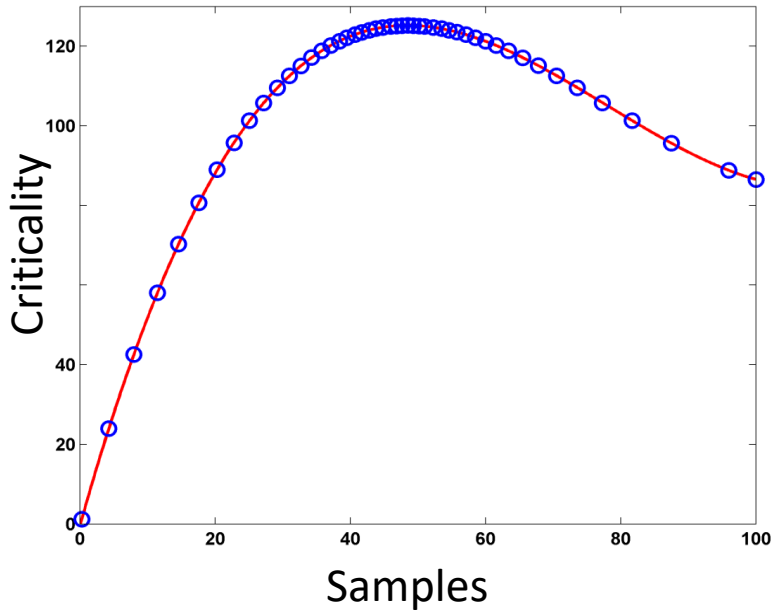
The problem

- Sensing requires energy
- Fundamental conflict between
  - Application needs:
    - more sensing
  - System limitations:
    - less sensing to conserve energy
- What is the optimal trade-off?



Adaptive Sensing

- Change amount of sampling over time
  - Increase during critical periods
  - Decrease at other times to conserve energy
- Model the energy conservation problem as a joint optimization problem for generating sensor control
  - information requirements
  - energy constraints



Two approaches

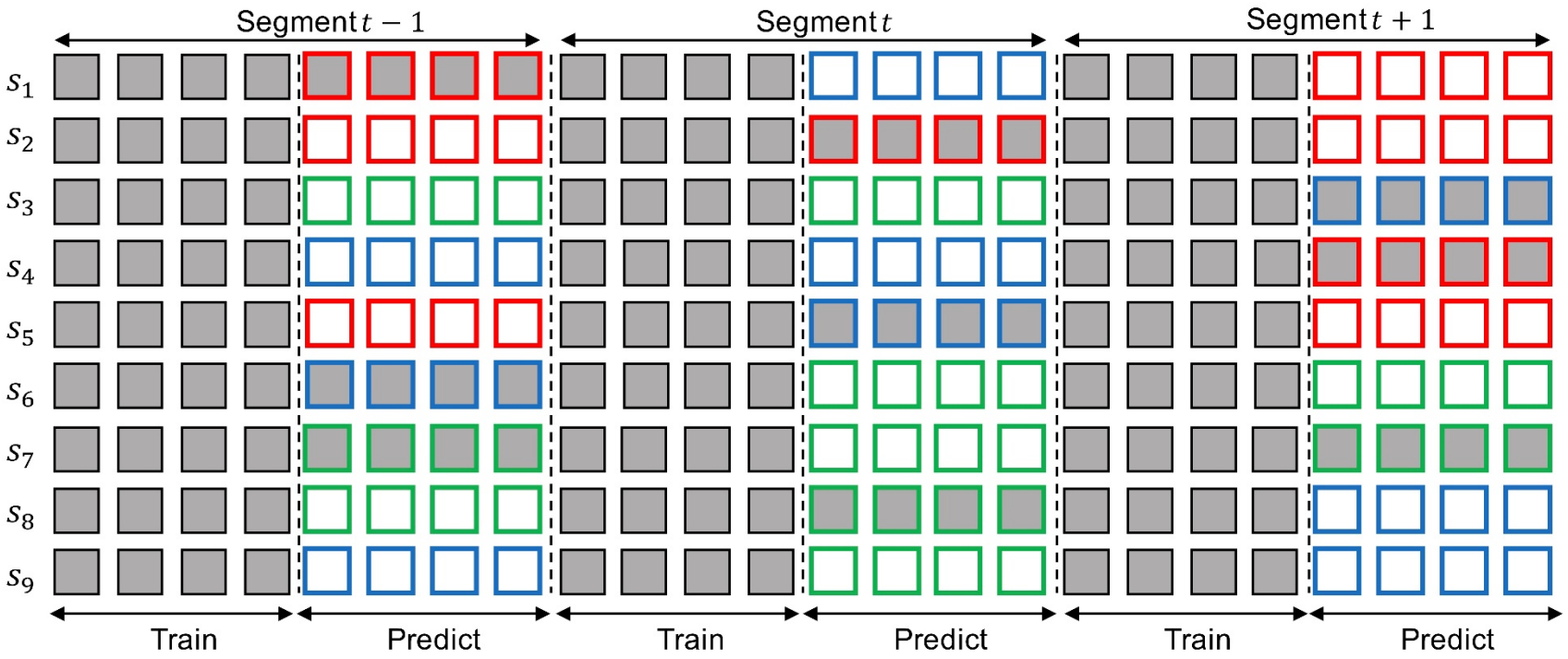
1. Clustering similar sensors
2. Stochastic modeling of energy-information trade-off

Clustering-based approach

Intuition:

- Value of the next reading of a sensor in a sensor collection can be approximated from the measurements of other *correlated* sensors
- Adaptive sensing in two steps:
  1. Group sensors that observe similar measurements
  2. Learn an estimation function, f , to predict a sensor measurement from the past measurements of other similar sensors in its group

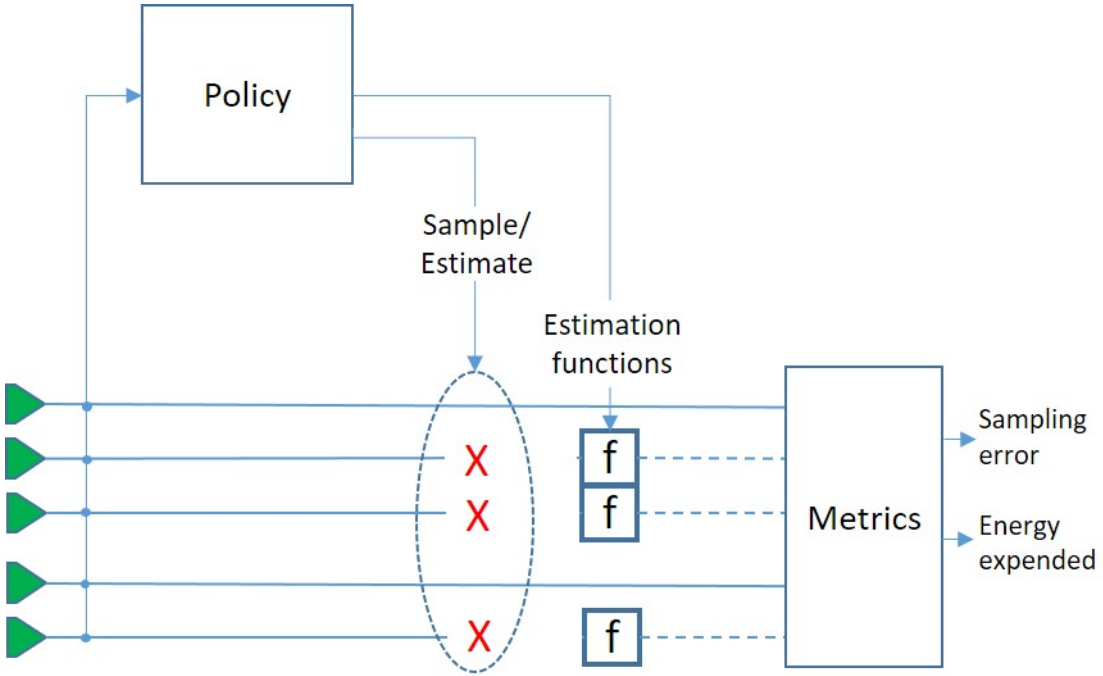
Clustering-based approach



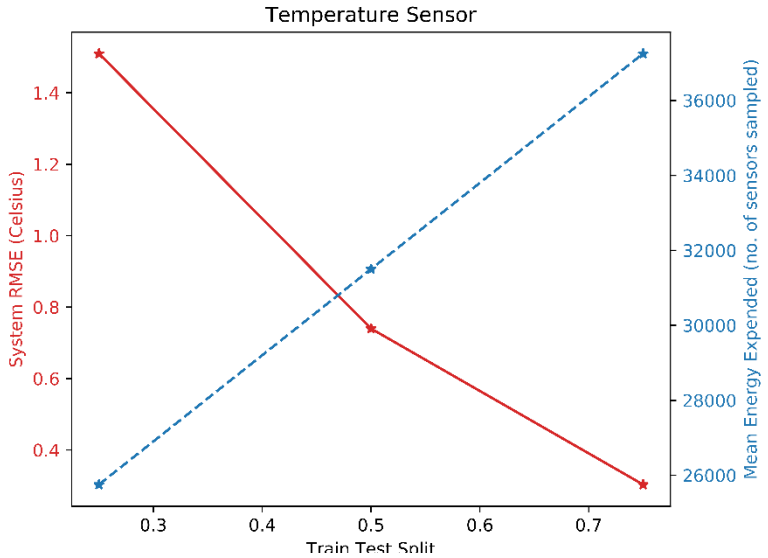
Approach parameters

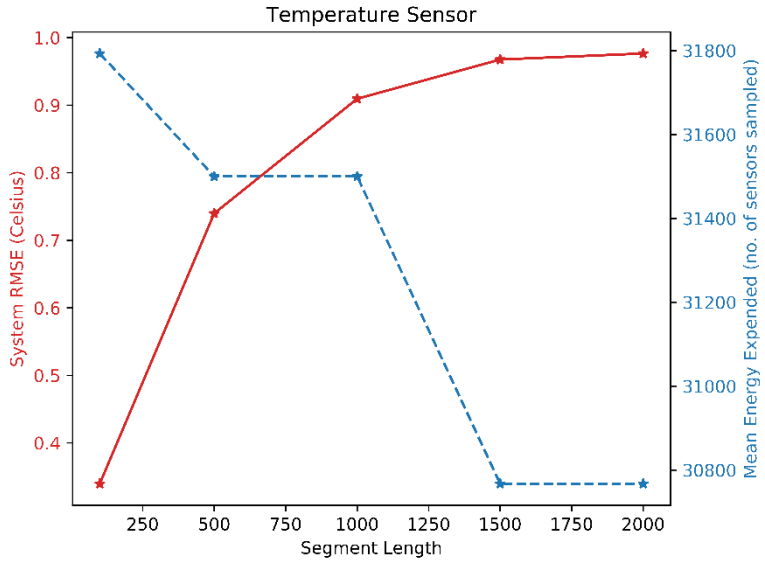
- Relative duration of train-predict periods
- Number of clusters
- Clustering algorithm
- Length of history used for prediction
- …
- Systematically, evaluate the relationship between these parameters

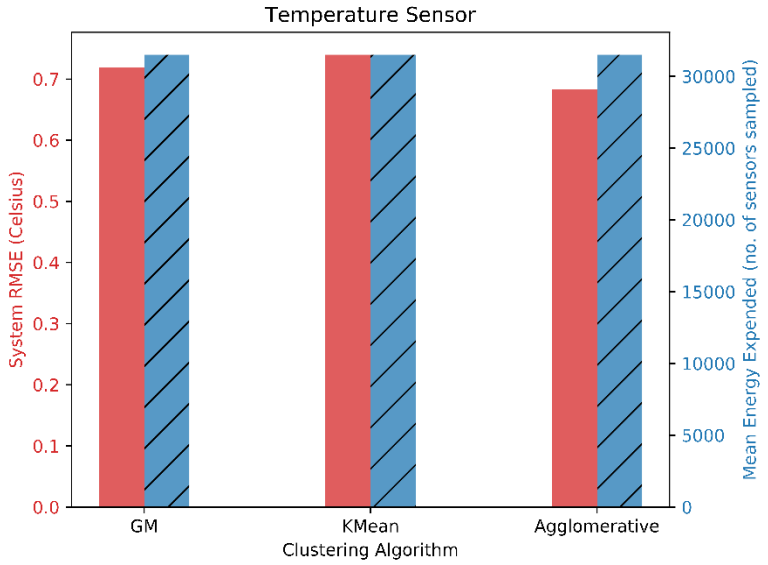
Evaluation setup

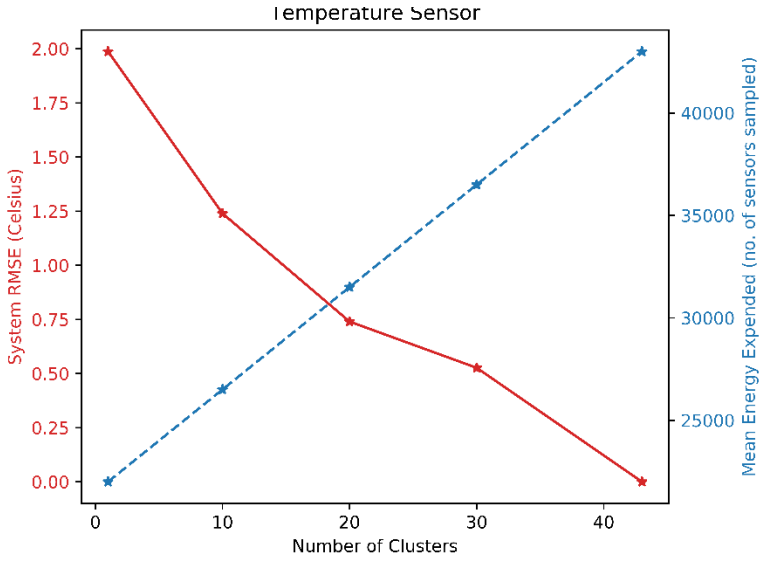


Simulation results







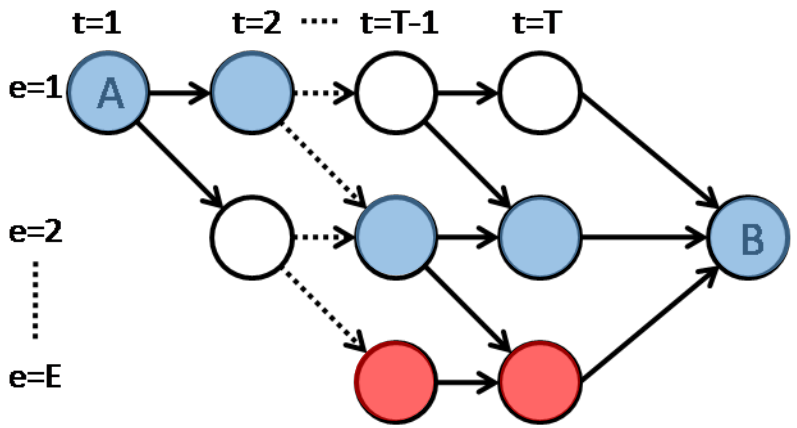


Stochastic modeling

- Use Markov Decision Processes (MDP) to model all factors affecting energy as a stochastic problem
- Solving the MDP gives a policy
  - Sensor sampling policy
- Generate the policy offline
  - Amortize the cost of planning
- Only write code to execute pre-computed policy on the mote
  - Simple table lookup

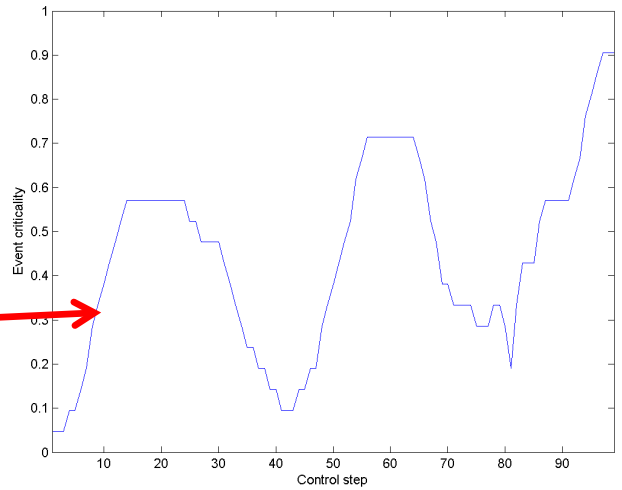
MDP Policy

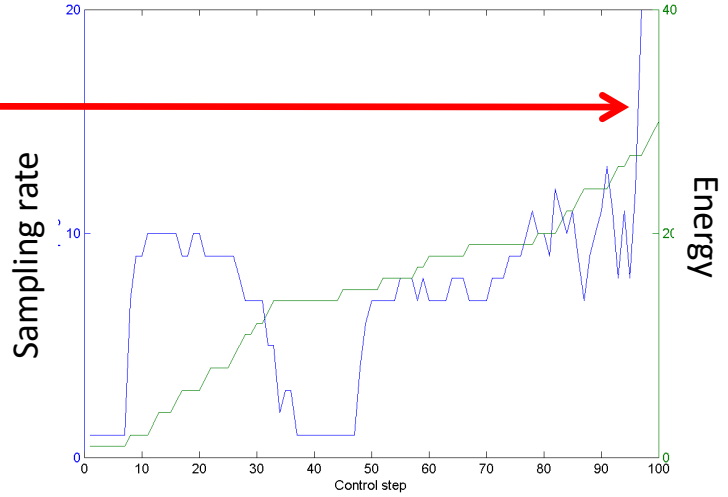
- A is the initial state
  - Full energy reserve
- B is the terminal state
  - End of simulation
- e=E states have run out of energy
- At every step:
  - Move right (t=t+1)
  - Move down is stochastic depends on sampling rate
- Move from A to B collecting reward
  - Don’t run out of energy
  - Sample at a high rate



MDP simulation

- T=100, P=30, H=10
  - 30,000 states
- Time-varying data criticality
- Sensor sampling rate depends on
  - Time to end of system lifetime
  - Data criticality
- Sampling rate increases at end of system lifetime
  - No value in having reserve energy, hence expend all on sensing





Some open problems

- Extend model to multiple sensors
  - Coordinated Sensing
  - Take advantage of sensor correlation
  - Take advantage of different sensor energy needs
- Learning the sensing policy
  - Reinforcement learning
  - Lifelong learning

Thank you!

Reconfigurable Solar Cells And Its Applications

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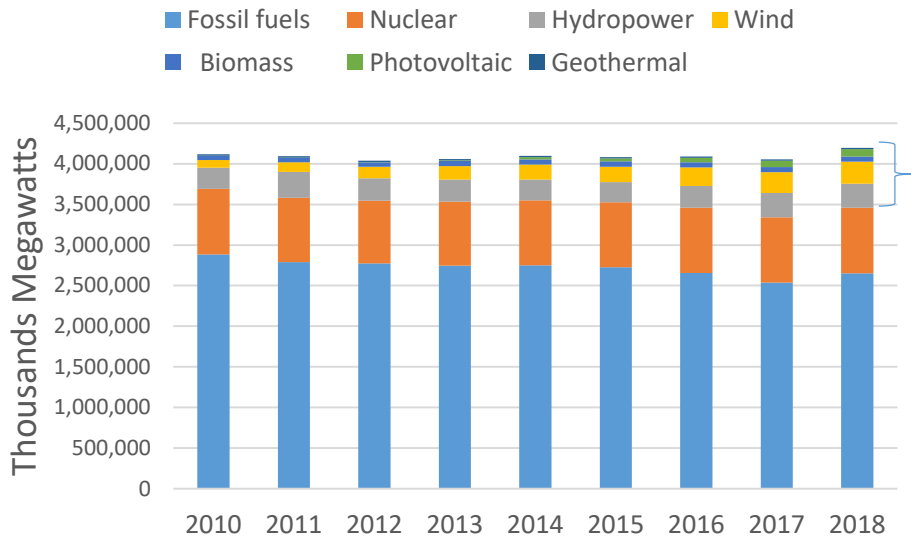
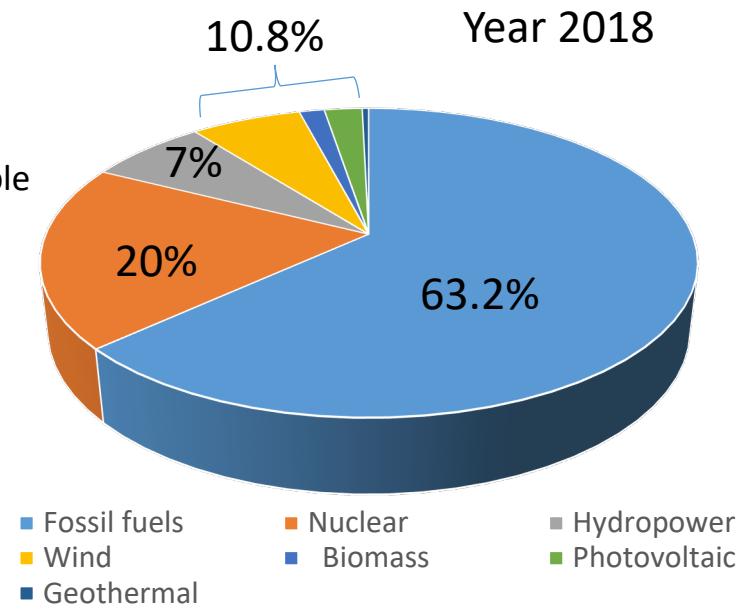
Outline

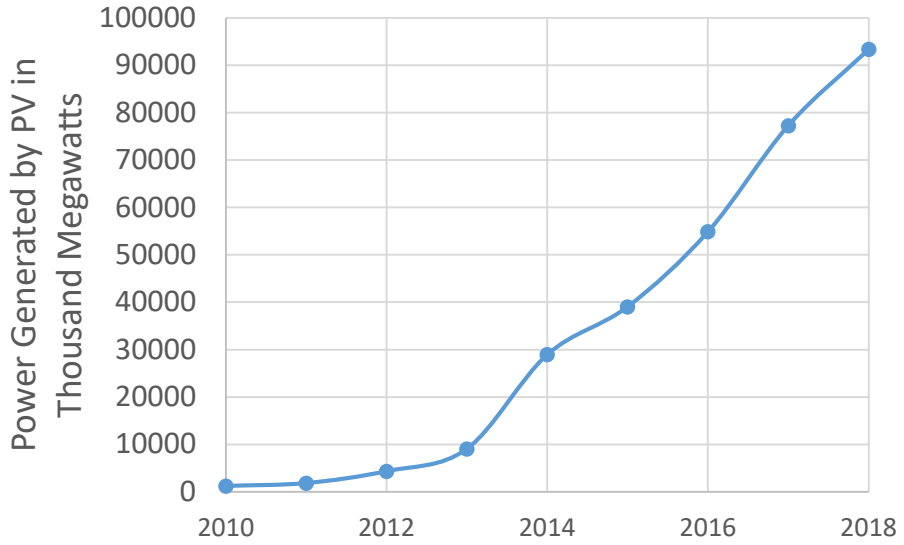
- Demographic
- Introduction
- Problems
- Existing solutions
- Our contribution
- Work in Progress
- Applications

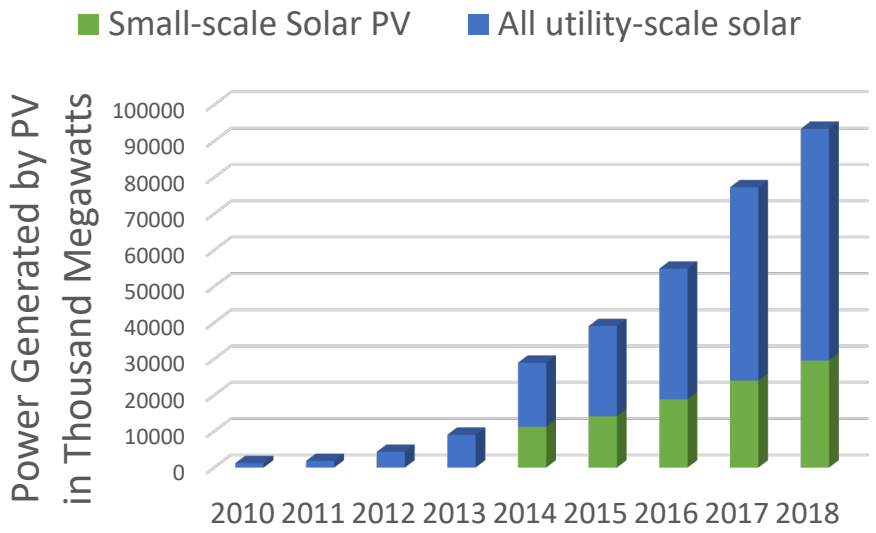
Total Power Generation in USA*



Renewable Energy







*Courtesy: https://www.eia.gov/

Average Solar Irradiation Across USA*

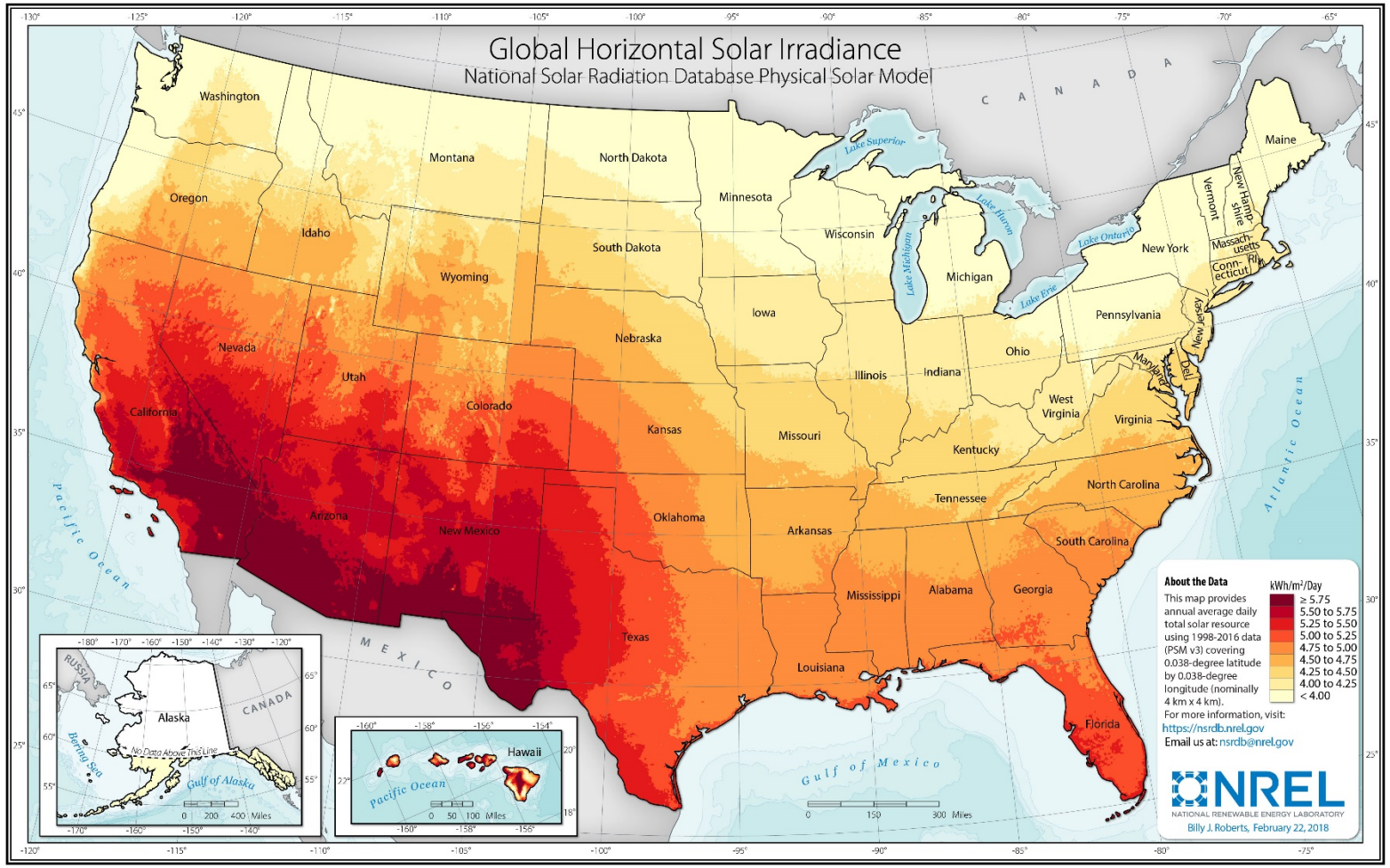
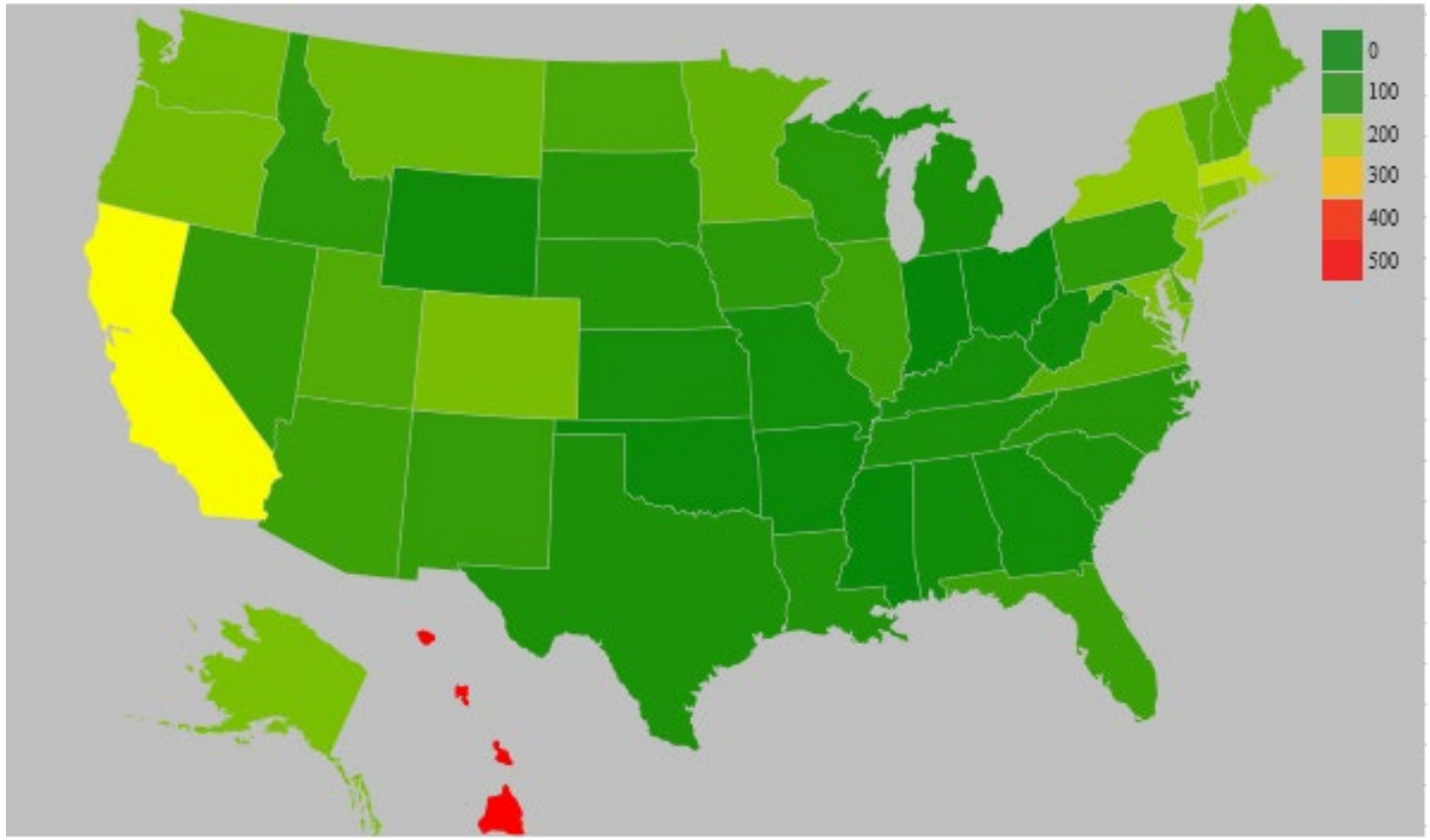


*Chart Courtesy: https://www.nrel.gov/

Nation’s Home Cost by Square Feet*



*Courtesy: https://www.Zillow.com/

Outline

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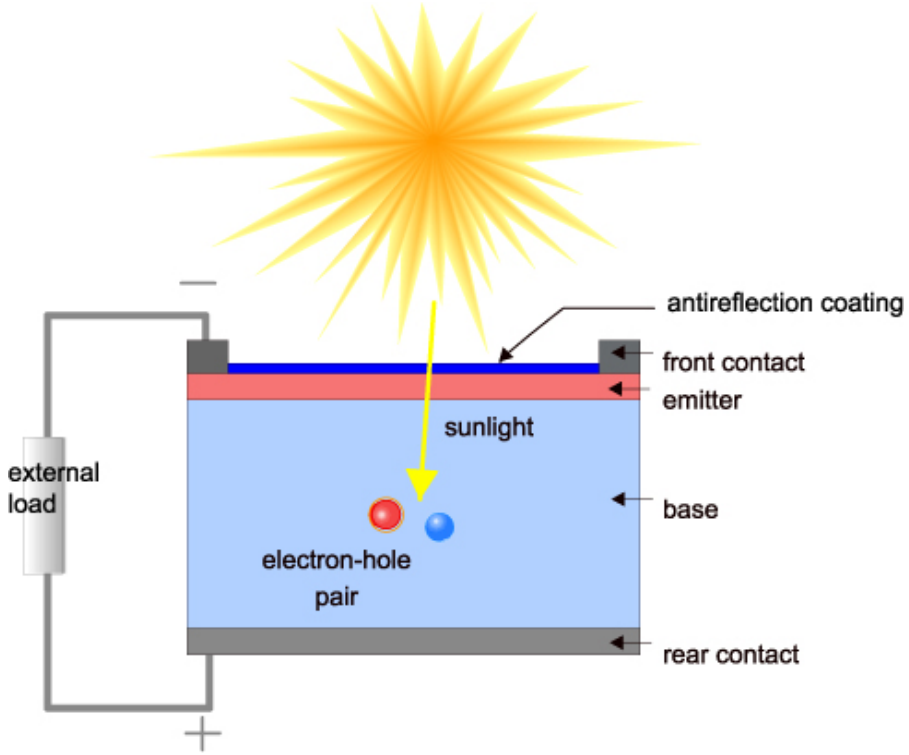
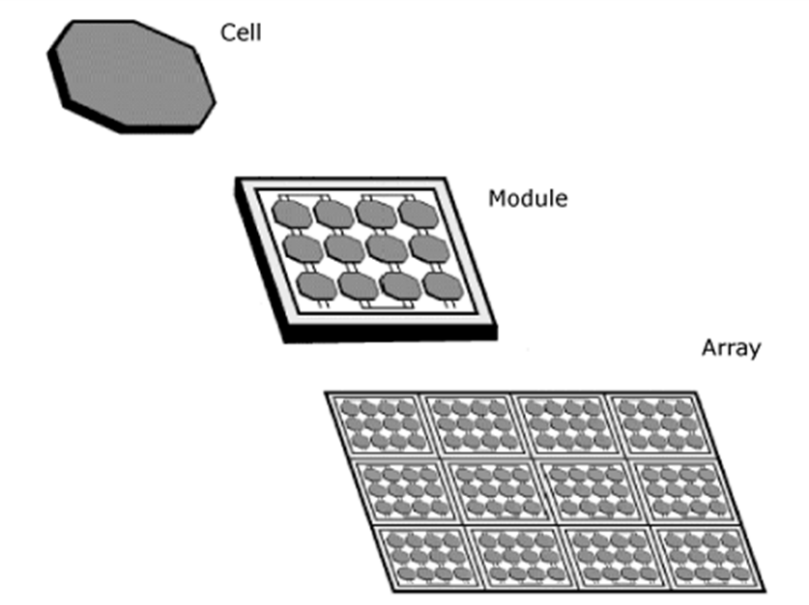
Introduction*

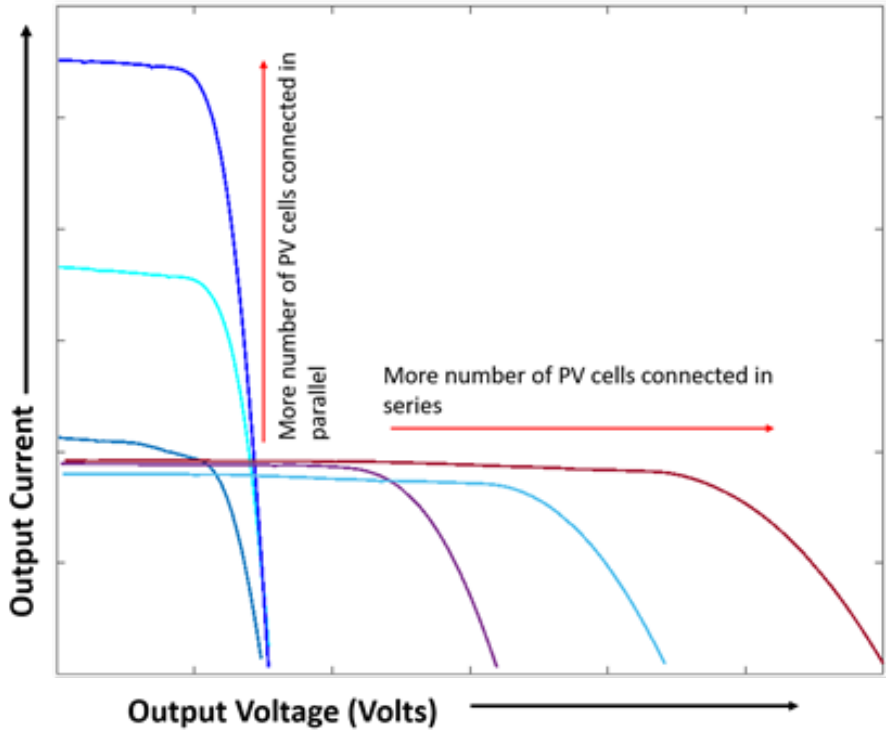
- A Solar cell is an electrical device that converts photons from the sun (sunlight) into electricity



*Pic Courtesy: http://www.pveducation.org

Solar Array*





* Pic Courtesy: National Energy Education Development Project

Outline

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Problems

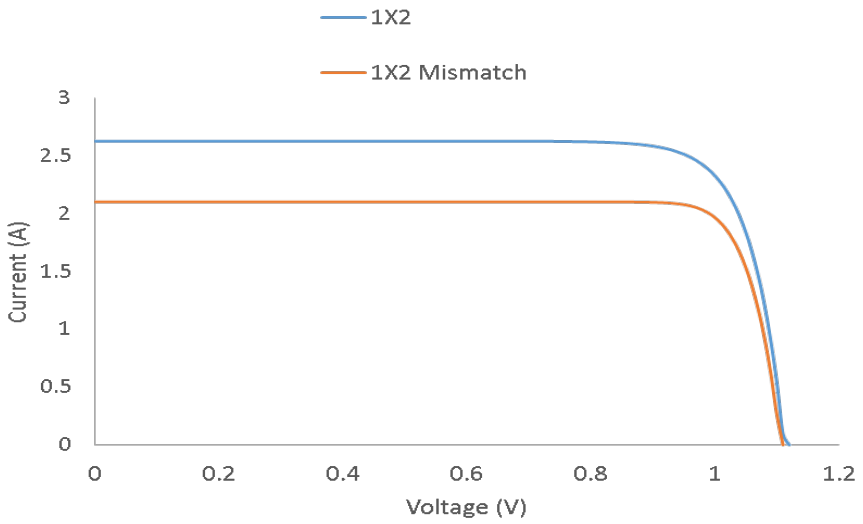
- Mismatch

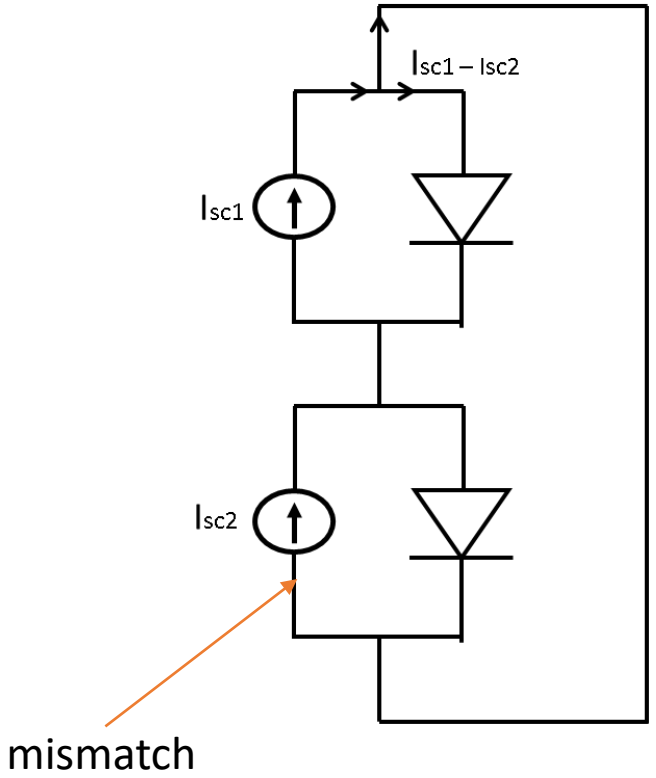
When panels are connected in series and one panel is underperforming, the entire "string" of panels produces less energy and the underperforming panel is one that is "mismatched".

Series connection mismatch*

- In series connection of PV cells, current controlled is by worst affected cell or cell under partial shading I_{sc2}
- Reduction in performance

Spice simulation for mismatch





*A. J. McEvoy, T. Markvart, and L. Castañer, Practical handbook of photovoltaics: fundamentals and applications, 2nd ed. Amsterdam: Elsevier, Academic Press, 2013.

Partial Shading*

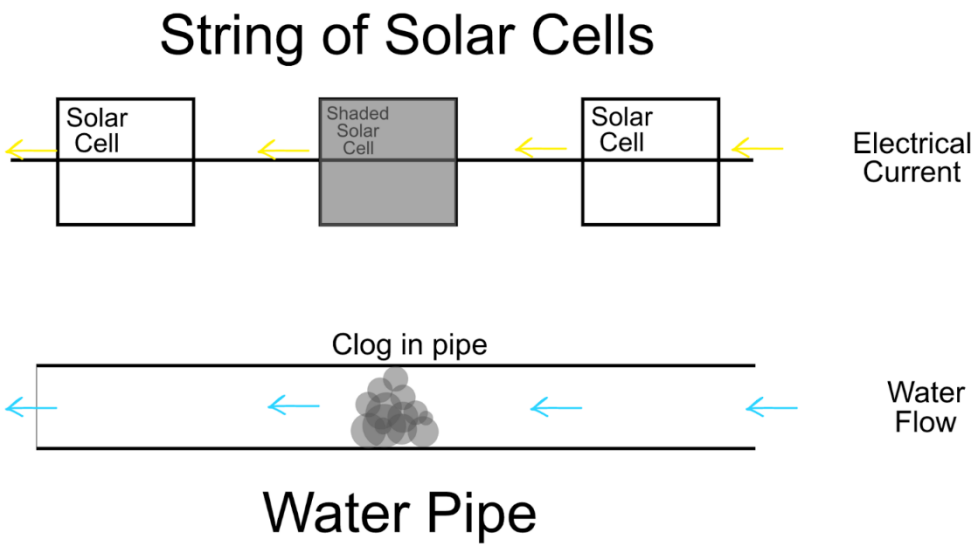
- Partial shading leads to reversed biasing of healthy PV cells in series
- Reversed biased PV cells consume power instead of generating power
- Reversed biased cell create local heating
- Creation of hotspot results in permanent damage of entire PV module

Pic courtesy : https://www.homepower.com

*A. J. McEvoy, T. Markvart, and L. Castañer, Practical handbook of photovoltaics: fundamentals and applications, 2nd ed. Amsterdam: Elsevier, Academic Press, 2013.

Analogy*

- A shaded solar cell is similar to a clog in water pipe

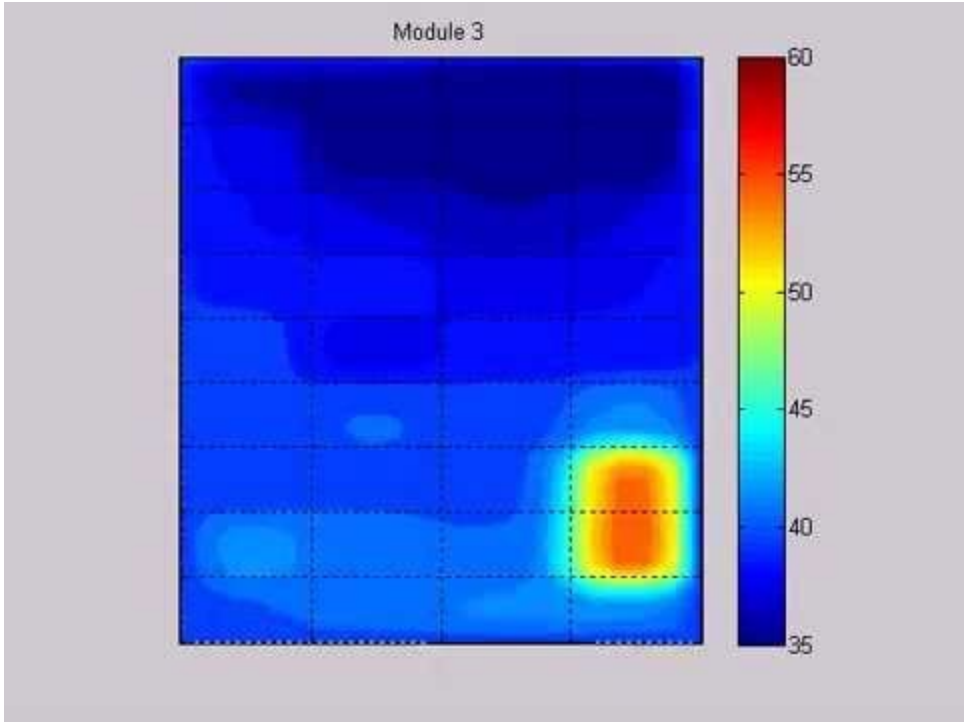


*Pic courtesy: http://blog.aurorasolar.com

Hotspot[1,2]

- “Walmart pins store fires on Tesla solar installs in new lawsuit”, https://www.pv-tech.org/news/walmart-pins-store-fires-on-tesla-solar-panels-in-new-lawsuit

2. Pic courtesy : https://www.firehouse.com/



1. Pic courtesy : https://www.pveducation.org/

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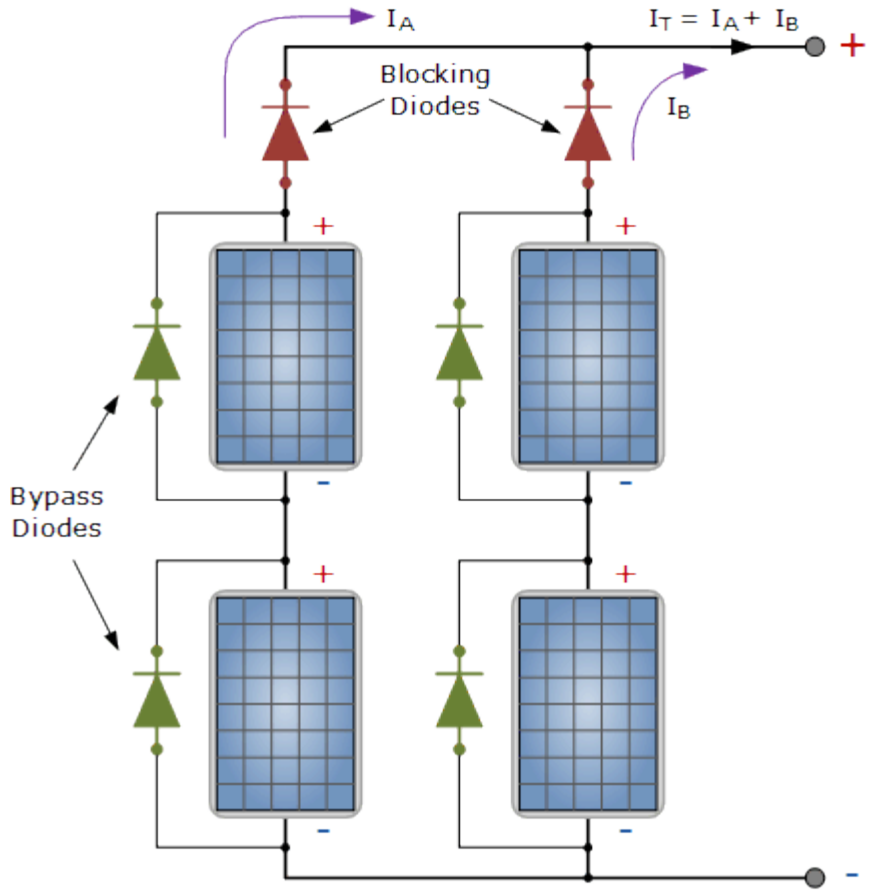
Existing Solutions*

Bypass Diode

- Bypass diodes allow current to pass around shaded cells and thereby reduce the voltage losses through the module.



*Pic courtesy: https://www.civicsolar.com

Limitations

What if the bypass diode fails?

1. **Short circuit**: Healthy PV cells connected across bypass diode will get bypassed (removed)
2. **Open circuit**: Hot-spot creation and eventually fire hazard

[1] N. A. Al-Rawi, M. M. Al-Kaisi, and D. J. Asfer, "Reliability of photovoltaic modules II. Interconnection and bypass diodes effects," Sol. Energy Mater. Sol. Cells, vol. 31, no. 4, pp. 469–480, Jan. 1994.
[2] N. G. Dhere, N. Shiradkar, E. Schneller, and V. Gade, "The reliability of bypass diodes in PV modules," 2013, vol. 8825, p. 88250I–88250I–8.

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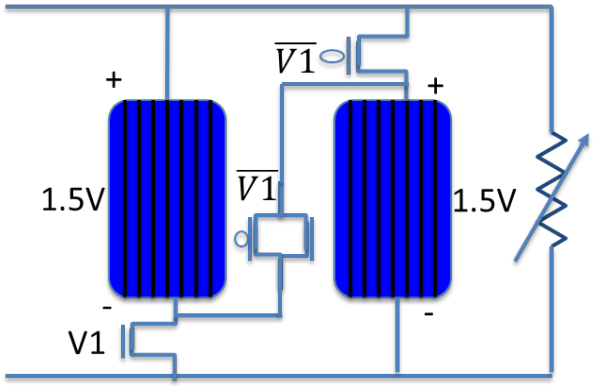
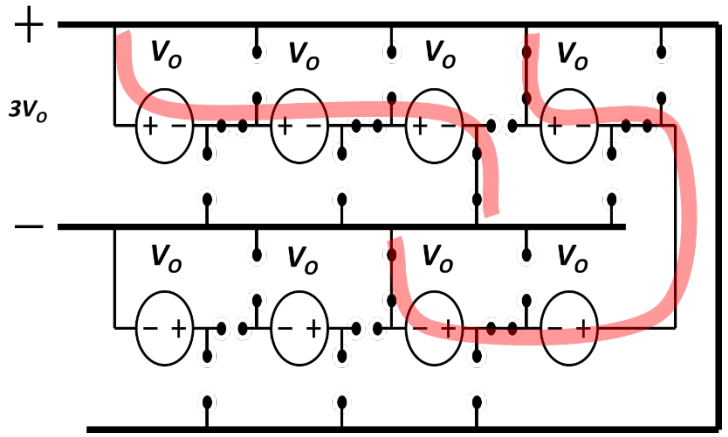
MOSFET based reconfigurable PV cells[1,2,3]

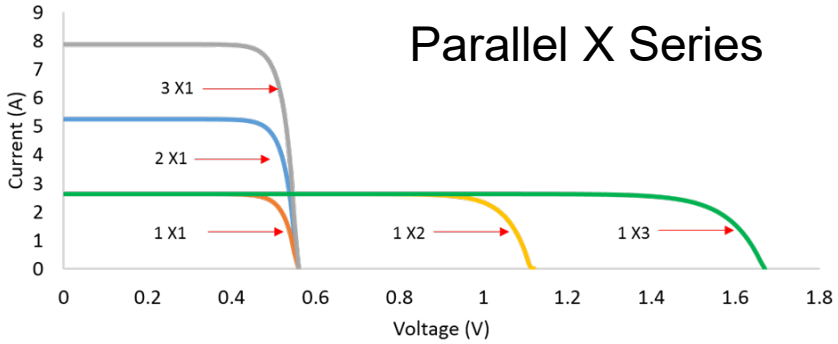
Reconfigurable PV Cells [1,2,3]



V1	High	Low
N-Switch	ON	OFF
P-Switch	ON	OFF
T-Switch	OFF	ON
	Parallel	Series



Voltage Vs Current

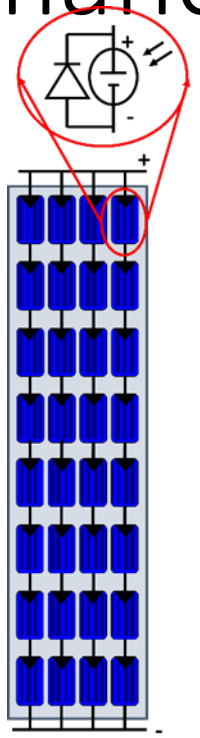


[1]J. West, S. Imani, O. Lavrova, W. Cavanaugh, J. Ju, K. Pupuhi, S. Keshavmurthy, J. Aarestad, and P. Zarkesh-Ha, "Reconfigurable power management using novel monolithically integrated CMOS-on-PV switch," in Photovoltaic Specialist Conference (PVSC), 2014 IEEE 40th, 2014, pp. 1389–1392

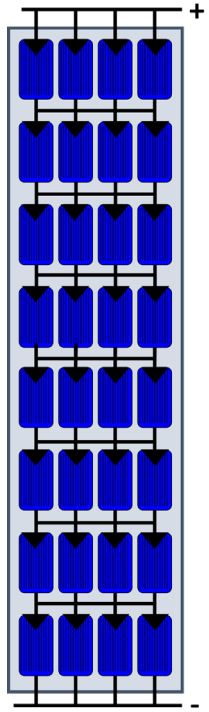
[2] X. Lin, Y. Wang, M. Pedram, J. Kim, and N. Chang, "Designing Fault-Tolerant Photovoltaic Systems," IEEE Des. Test, vol. 31, no. 3, pp. 76–84, Jun. 2014

[3] R. Mahto, O. Lavrova, P. Zarkesh-Ha, and L. Lester, "Reconfigurable and Programmable Photovoltaic Power for Micro Autonomous Systems," in ReSpace/MAPLD 2011, Albuquerque, NM, 2010.

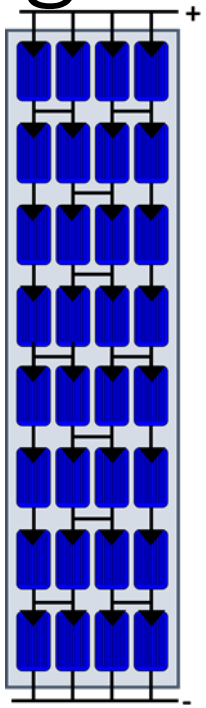
Performance in Shading Mitigation



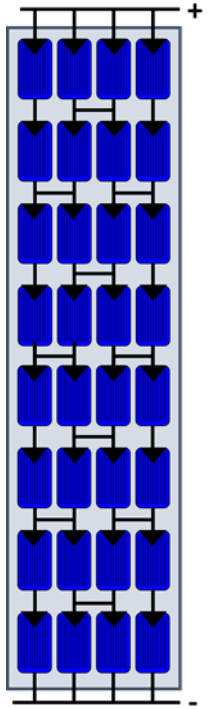
Series- Parallel



Total Crossed-Tied

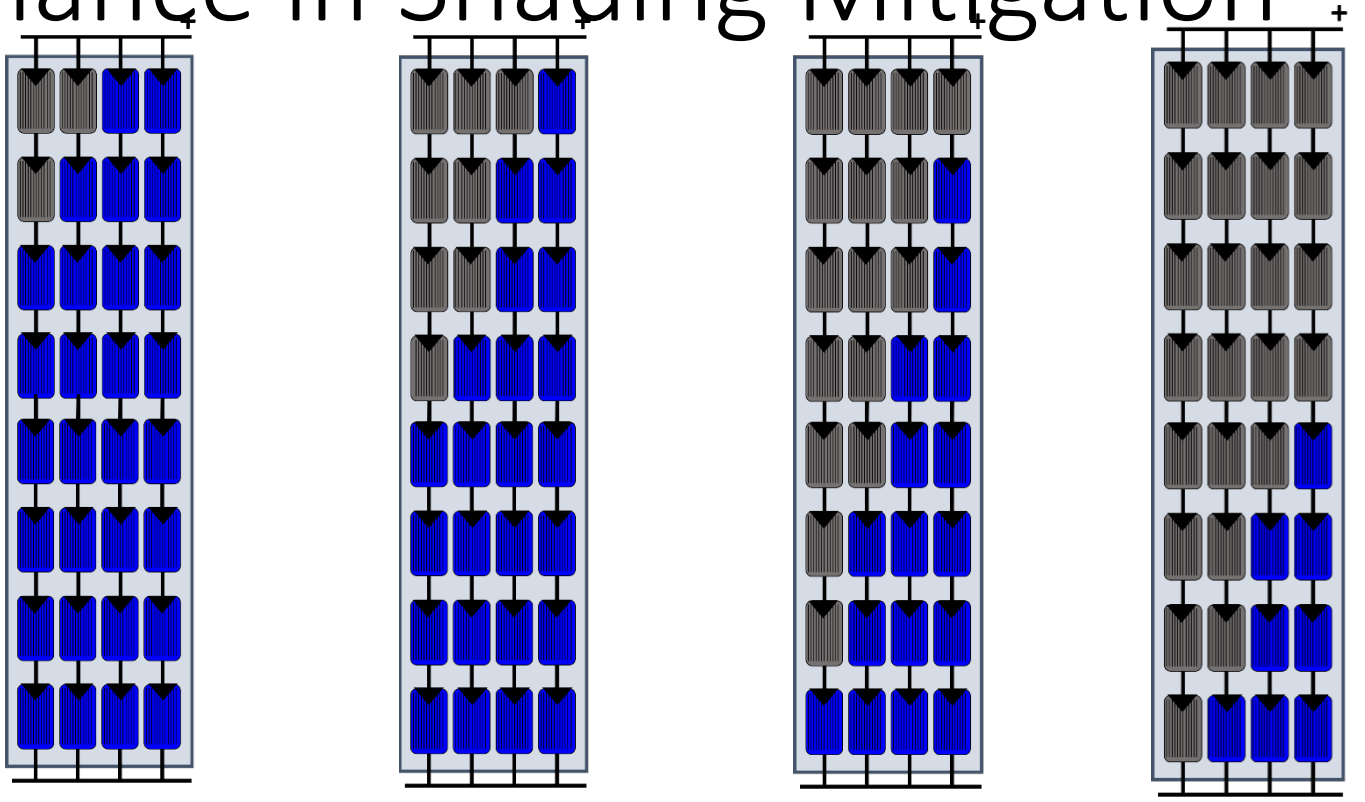


Honeycomb



Bridge Linked

Performance in Shading Mitigation



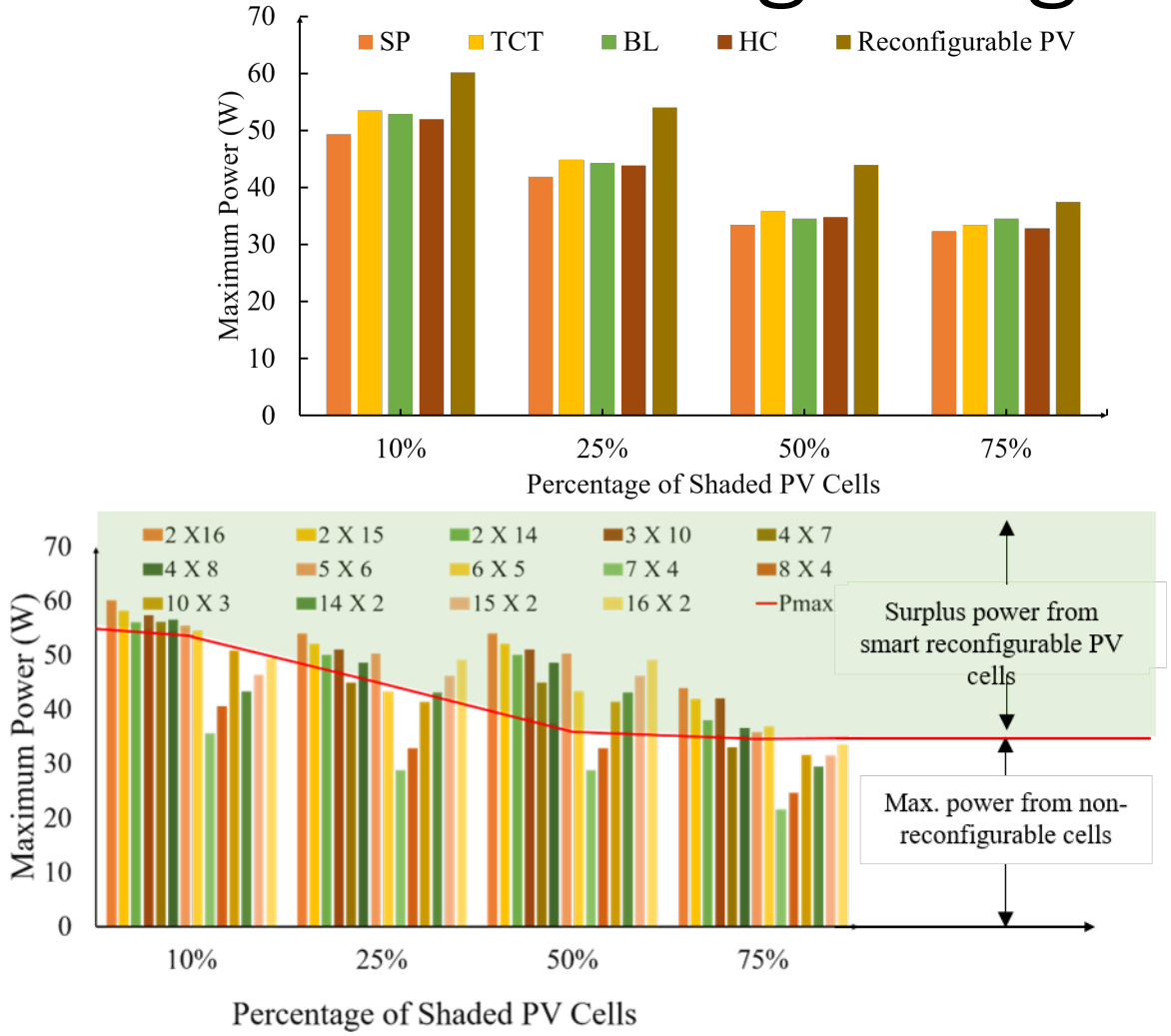
10% Shading

25% Shading

50% Shading

75% Shading

Performance in Shading Mitigation[1,2]



1. Raghavan R, SCCUR, 2018
2. D. Xavier at el. , IEEE SusTech 2018

Outline

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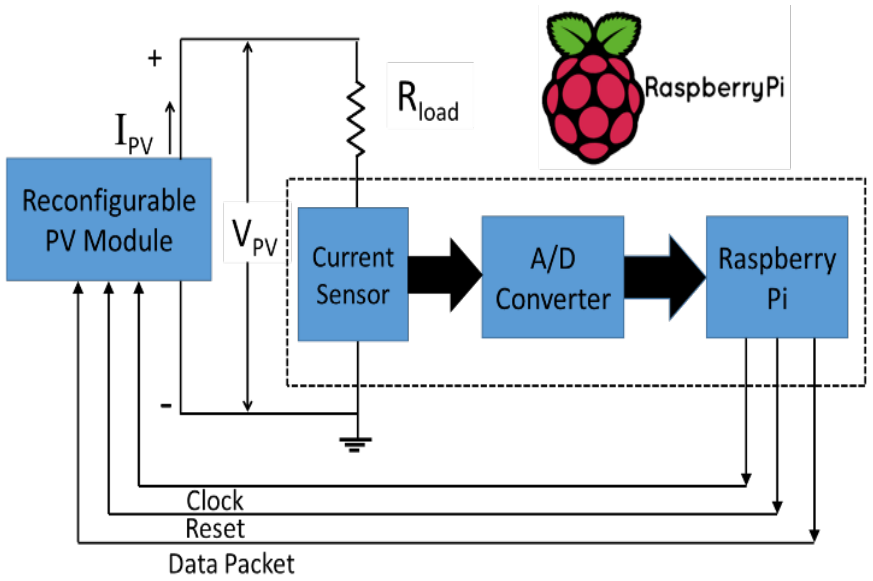
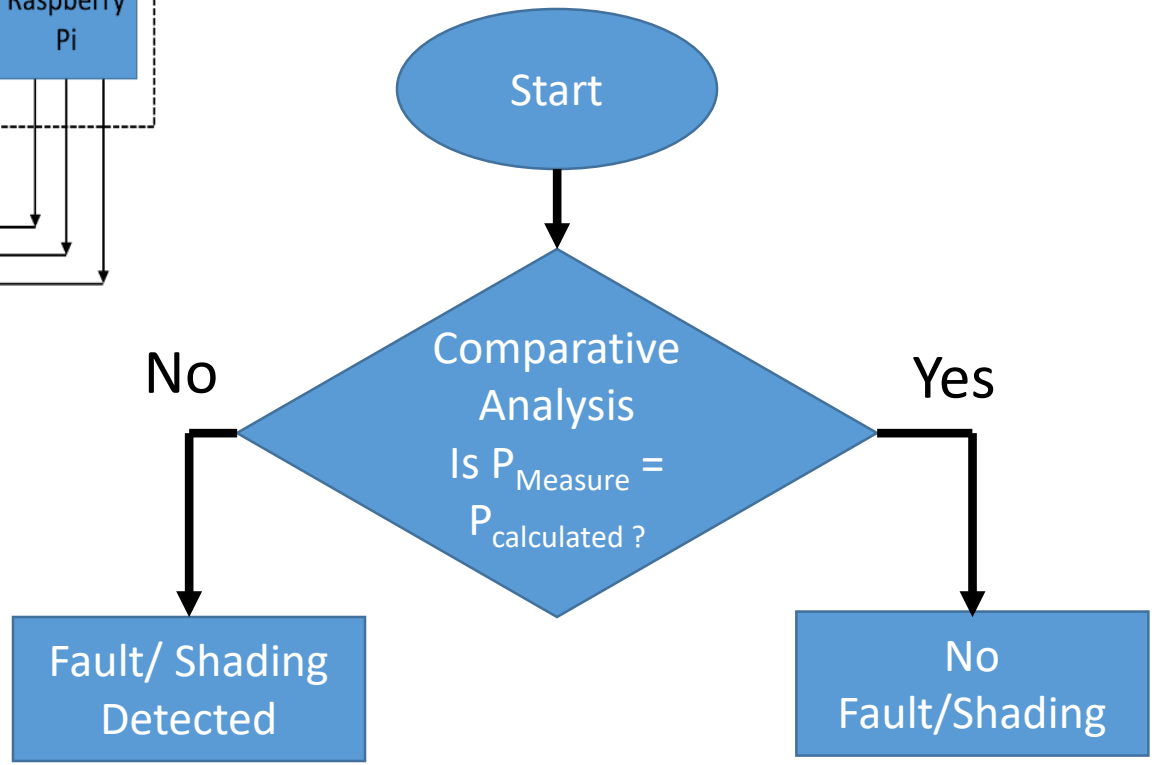
Complete Reconfigurable PV System*

System



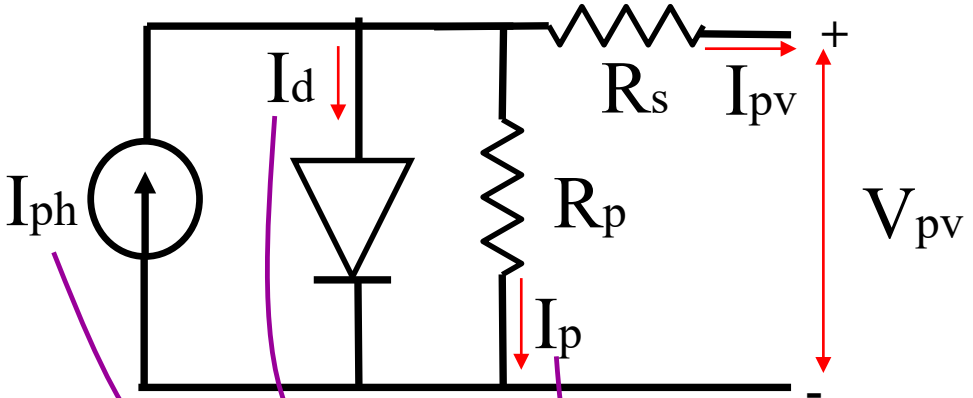
Algorithm



*R. Mahto, "Fault Resilient and Reconfigurable Power Management Using Photovoltaic Integrated with CMOS Switches," University of New Mexico (2016).

Photovoltaic (PV) modeling

Single Diode based PV cell modeling*



$$I_{PV} = I_{Ph} - I_d - I_P$$

I_{PV} = Output current
V_{PV}= Output voltage
Rp= Shunt resistance
Rs= Series resistance
A= Diode quality factor
Is= Diode saturation current
I_{ph}= Photon current
Vt= Thermal voltage= 26mV

Output Current

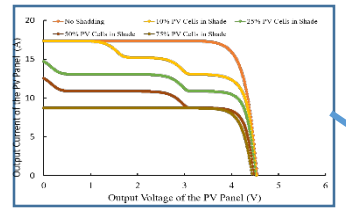
$$I_{PV} = I_{Ph} - I_s\left(e^{\left(\frac{V_{PV}+I_{PV}\cdot R_S}{A\cdot V_t}\right)} - 1\right) - \left(\frac{V_{PV} + I_{PV}\cdot R_S}{R_P}\right)$$

Exponential Term

*H. Park and H. Kim, "PV cell modeling on single-diode equivalent circuit," in IECON 2013 - 39th Annual Conference of the IEEE Industrial Electronics Society, 2013, pp. 1845–1849.

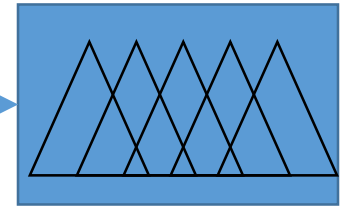
Fuzzy Logic

- Fuzzy logic system will receive I-V characteristics
- Current number of PV cells in series vs parallel
- Predict optimal configuration of reconfigurable PV module



Number of PV in Series and Parallel

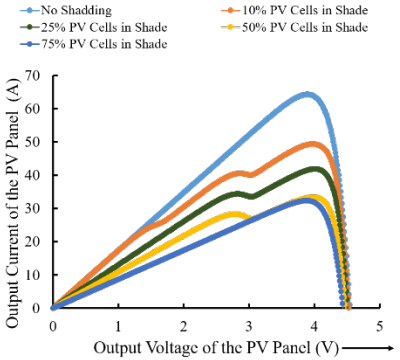
Fuzzy Logic



Best Possible Configuration

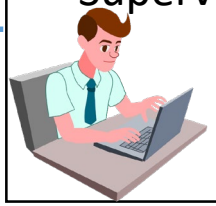
Machine Learning

Input Raw Data

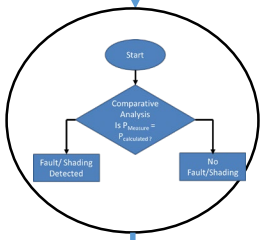


Training Data Set

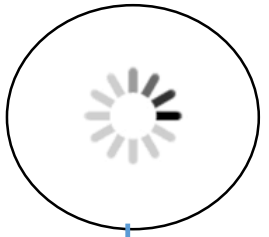
Supervisor



Desired N_S N_P



Algorithm



Processing

Output

Ns

Np

Power

Critical Application

- These type PV module can power
  - IoT enable smart PV for powering residential and commercial buildings
  - Satellite
  - Drone
  - Vehicles

Thank you!

The Design of Low-Voltage Low-Power Analog Integrated Circuits

Presenter: Yitsen Ku, Ph.D.
Department of Electrical Engineering,
California State University, Fullerton, USA

Publications in the last 5 years

- I have published 28 international journal papers in last 5 years including 13 IEEE journal papers.
- In addition, I have presented and published 6 international conference papers in last 5 years.

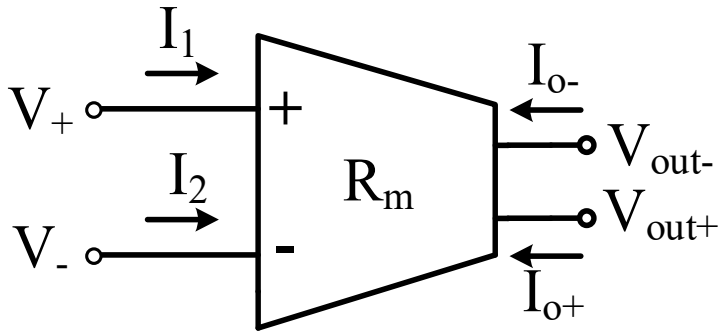
My Research Area

- My research areas focus on the low-voltage low-power analog integrated circuit (IC) design, including active component IC design and power IC design.

Publications in 2019

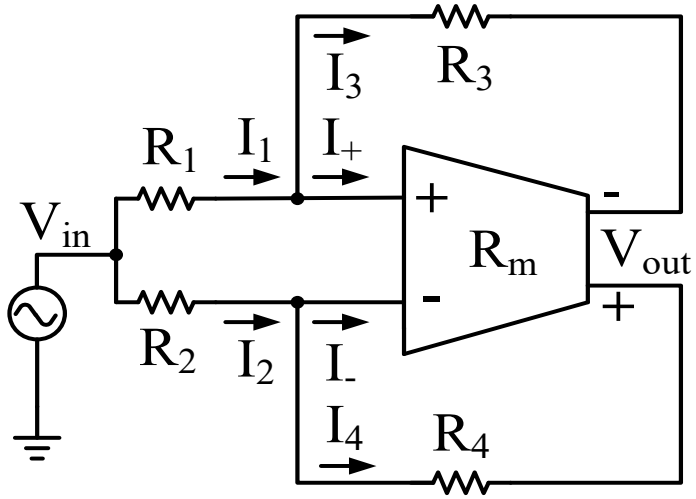
- In 2019, I published eight (8) international journal articles under the name of the Electrical Engineering Department of the California State University Fullerton. Two (2) out of these 8 papers, are IEEE journal articles.
- Among 8 publications, three (3) papers are on power integrated circuits, four (4) on active component integrated circuits, and one (1) on supply modulator integrated circuit.

Proposed FDOTRA and CMWB



$$V_{out+} = V_{o+} = (I_1 - I_2) \times R_m$$
$$V_{out-} = V_{o-} = (I_2 - I_1) \times R_m$$

(a) Proposed FDOTRA



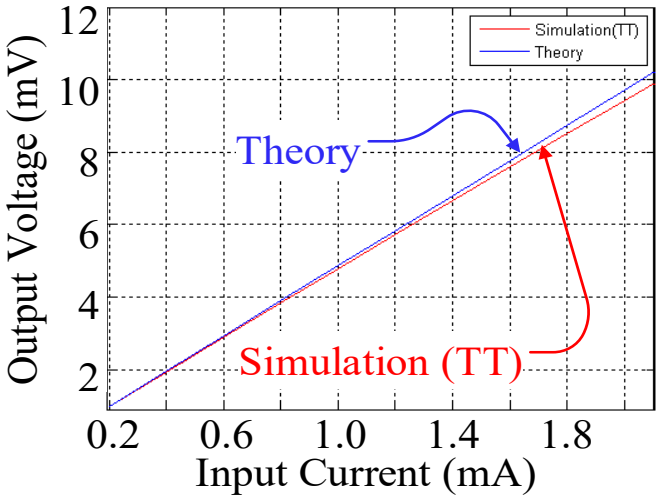
$$R_1 = R_o \mp \Delta R$$
$$R_2 = R_o \pm \Delta R$$
$$R_3 = R_4 = R_L$$
$$V_{out} = \frac{\pm \Delta R}{R_o} I_{in} R_L$$

(b) Proposed CMWB

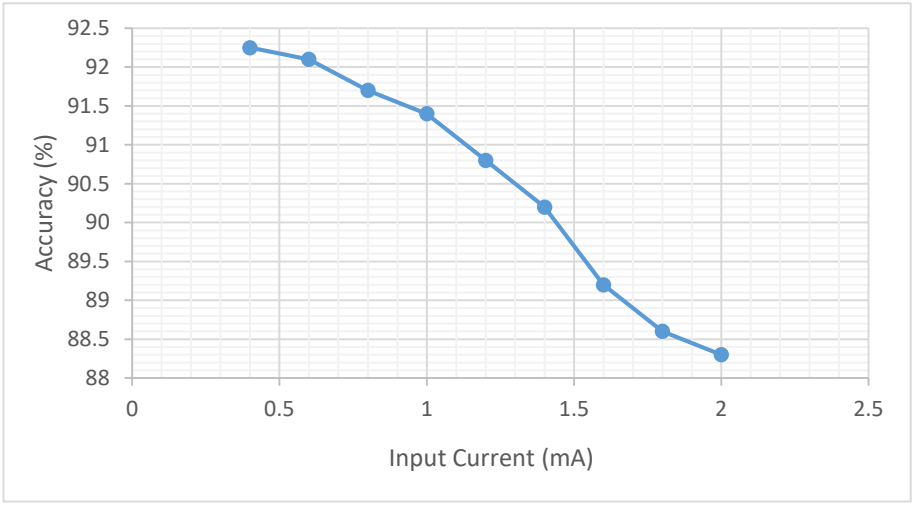
FDOTRA: Fully Differential Operational Trans-conductance Amplifier

CMWB: Current-Mode Wheatstone Bridge

Simulation and Experiment



(a) The V_{out}/I_{in} of the proposed CMWB



(b) The measurement result of the proposed CMWB accuracy

Current and Future Research

- IC design needs to be fabricated and validated. Taiwan Semiconductor Manufacturing Company offers free fabricated for educational purposes. However, American Semiconductor Manufacturing companies did not. Thus, I will continue to cooperate with researchers in Taiwan in IC design.
- My master's degree focuses on computer engineering, and I am currently teaching computer engineering courses, so I am also considering research in the field of computer engineering.

Thanks