Addressing the challenges of Interdisciplinarity

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&
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About the panel

Alex Simpkins, Ph.D.

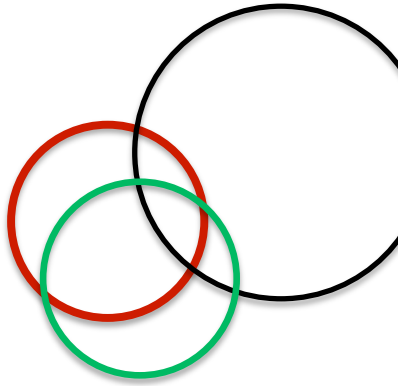
- BS Psych/BS AMES
- MS/PhD ME UCSD
- Research interests:
  - Multi-scale theory and practice
  - Control theory/Design
    - Coordinated control of movement
  - Active learning, learning in biological and artificial sys.
  - Robotics
- Teaching experience:
  - 21/2, variety of engineering, psych, cogsci

Martina Rau

- Currently Ph.D. student in HCI
- BA Psych; MA Psych / Cog Sci; MS HCI
- Research interests:
  - Intelligent tutoring systems
  - Learning with graphical representations
- Teaching / TA experience:
  - Intelligent tutoring systems for prospective teachers
  - Classical theories of learning
  - HCI methods

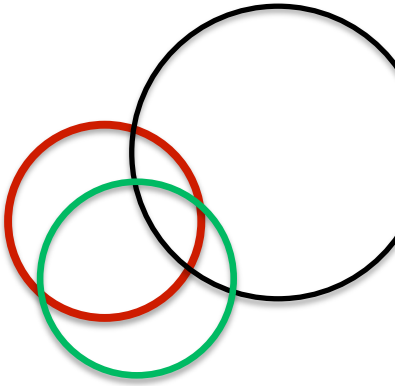
Introductions: Your turn!

- Your name
- Your center and institution
- What disciplines were you trained in?



Outline

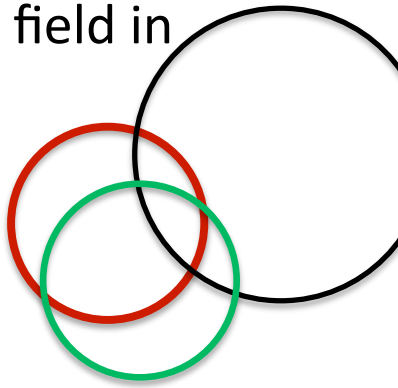
1. What is interdisciplinarity?
   - Overview
   - Group session
2. Why should we do interdisciplinary work?
   - Pros and cons
   - Examples of successful interdisciplinary work
3. How can we enhance research and application through interdisciplinary work?
4. What challenges can we expect to face?
   - And what opportunities arise from them?
5. Conclusion



1. WHAT IS INTERDISCIPLINARITY?

Defining Interdisciplinarity

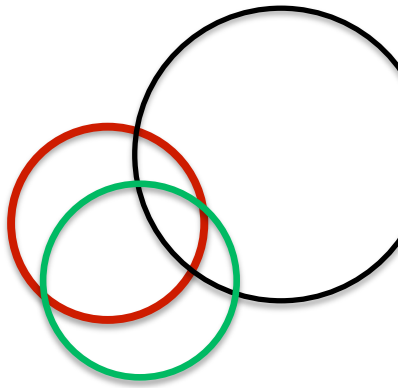
- There is more than one definition
- “A mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines […] to solve problems whose solutions are beyond the scope of a single discipline […].” [3]
- “Interdisciplinarity involves the combining of two or more academic fields into one single discipline. An interdisciplinary field crosses traditional boundaries between academic disciplines or schools of thoughts, as new needs and professions have emerged.” [4]
- Perspective of a researcher or practitioner (e.g. a teacher) with a home field, who branches out to integrate at least one other field in their work



Contrasting definitions of interdisciplinarity [5]

Level of cross-discipline integration

- *Intradisciplinarity*: concentrated within a single discipline
- *Crossdisciplinarity*: involves insights from one discipline which are viewed from the perspective of another discipline
- *Multidisciplinarity*: uses perspectives drawn from several different disciplines
- ***Interdisciplinarity***: makes an effort to integrate insights found in a number of disciplines
- *Transdisciplinarity*: seeks to integrate disciplinary insights to the extent that existing disciplines disappear in the emergence of a new field



(Inter-)disciplinarity in the learning sciences

- Psychology
- Computer science & engineering
- Instructional design
- Human-computer interaction
- Linguistics
- Statistics
- Economy
- Machine learning/AI
- Neuroscience
- Education

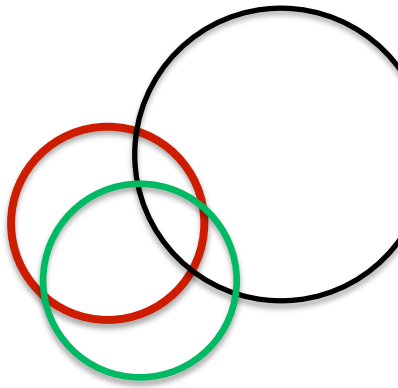
Learning sciences

Small-group discussions: How does your research, as situated in one or more of these disciplines, contribute to the learning sciences?

2. WHY SHOULD WE DO INTERDISCIPLINARY WORK?

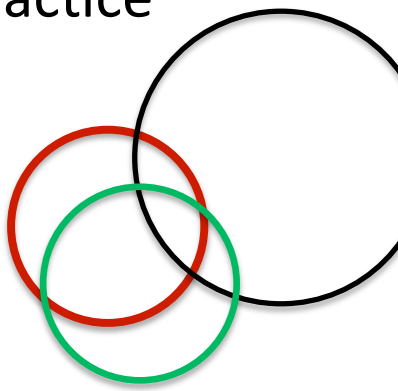
What are common concerns in performing interdisciplinary research?

- Interdisciplinary scholars may feel they have to fight for identity [7]
- They might not 'feel at home' in any discipline be accused of lacking the expertise in all of them [8]
- They may not seem to fit into traditional academic structures [6]
  - Tenure decisions often favor disciplinary scholars [9]
- It appears to be really hard!
  - It's also a resource



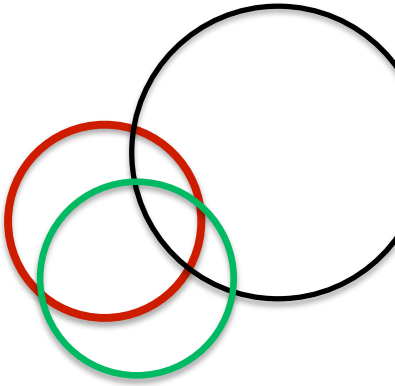
What is to be gained by doing interdisciplinary research?

- It's the trend [5]
  - In 2011, 30-40% of all proposal requests by NSF explicitly required interdisciplinary approach [6]
  - Between 1973 and 2005, the number of interdisciplinary bachelors degrees rose from 7,000 to 30,000 [11]
- Potential to relate to a broader audience and to reach practitioners [12]
- Real-world problems can often not be answered by one discipline alone, but typically bridge many disciplines [12]
- Interdisciplinary research may have higher impact on practice [5]



Some success stories

- Many a great invention, discovery, or contribution has occurred this way
  - Founders of science were philosophers, typically many-fielded
    - Plato
    - Aristotle
  - Integration of open minds often leads to unexpected solutions
    - Galvani – Electrical properties of the skin of frogs
      - Accidental kick, thought electricity was confined to muscles
    - Volta – invented the battery to prove him wrong (electricity can flow outside the body)! (Thanks neuroscience!)
    - 3M and sticky notes



Some more success stories

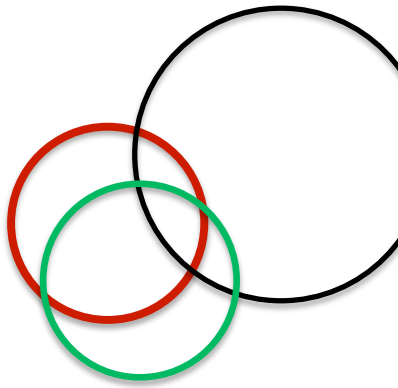
- Often one field has the answer to a problem prevalent in another field
- Many famous scientists have been born out of the 'interdisciplinary' movement:
  - Thomas Edison: Lightbulb, AC power, first film studio, carbon telephone transmitter – used till 1980, etc
  - Leonardo da Vinci: Painter, sculptor, architect, musician, scientist, mathematician, engineer, inventor, anatomist, geologist, cartographer, botanist, and writer
    - "Unquenchable curiosity"
  - Gottfried Wilhelm Leibniz: Infinitesimal calculus, contr. Binary number system, logic, analytic philosophy, physics, biology, medicine, geology, prob. Theory, psychology, philology, linguistics, information science, politics, law, ethics, theology, history, etc

And more success stories

- Santiago Ramón y Cajal
  - Pathologist, histologist, neuroscientist, Nobel laureate, 'Father of modern neuroscience,' neuroanatomy, 'neuron theory,' science fiction writer, artist, draftsman, photographer, and published on hypnosis
- Hermann von Helmholtz:
  - Mechanics, optics, sensory and nerve physiology, aesthetics, acoustics, electromagnetism, etc
- Benjamin Franklin
  - Author, printer, political theorist, politician, postmaster, scientist, musician, inventor, satirist, civic activist, statesman, and diplomat
  - Invented the lightning rod, bifocals, the Franklin stove, a carriage odometer, and the glass 'armonica'. He formed both the first public lending library in America and the first fire department in Pennsylvania.

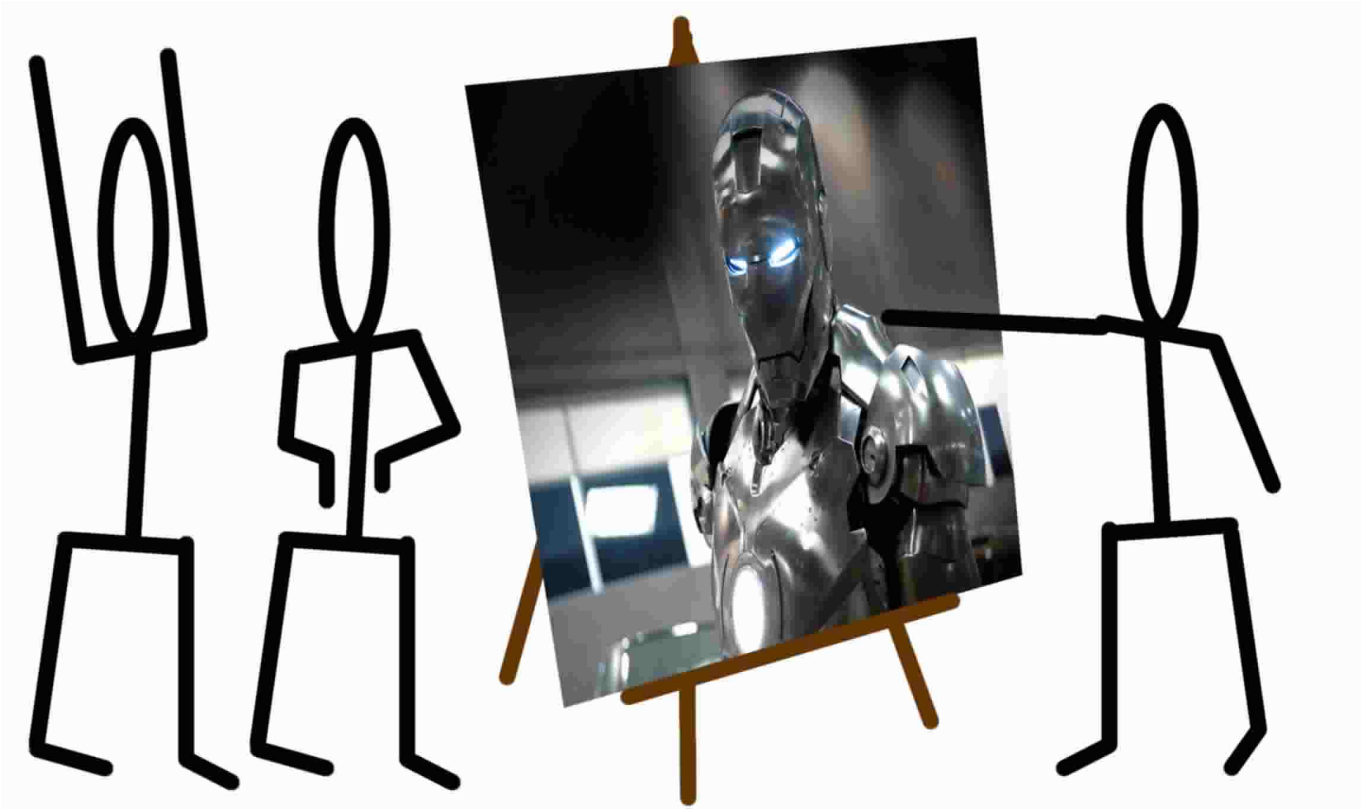
Even more success stories – by our peers!

- ME/Neuroscience
  - They don't seem related do they?
  - Dissertation award 2011 at UCSB's ME department
    - "Dynamical Characterization and Feedback Control of Oscillatory Neural Systems" [13]

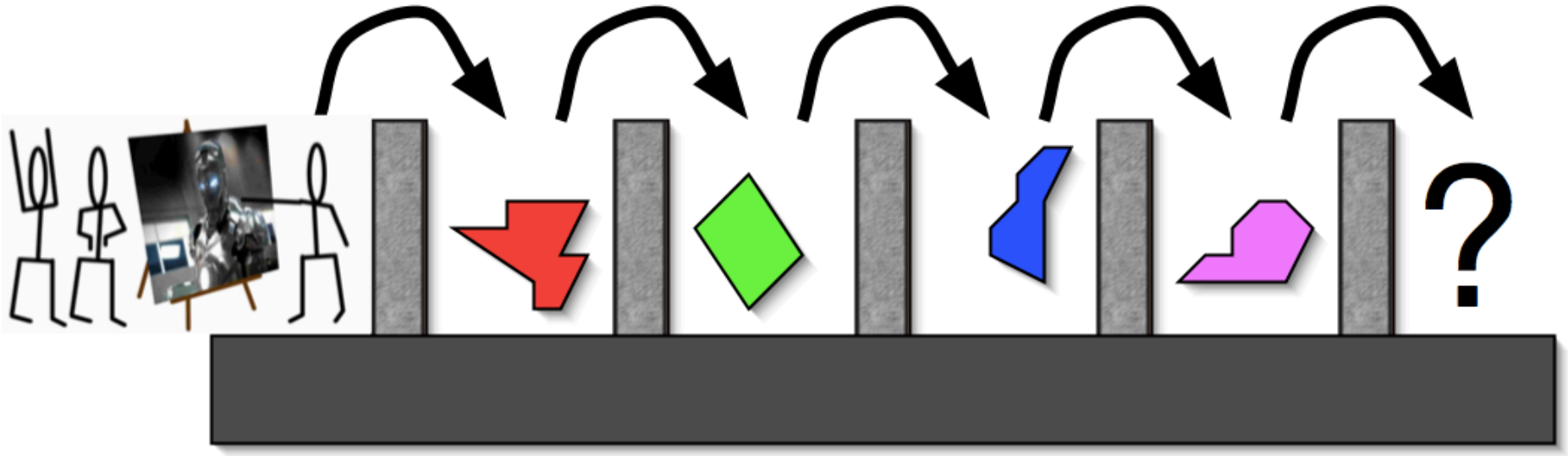


Historical parallels

- Over-the-wall vs. concurrent engineering

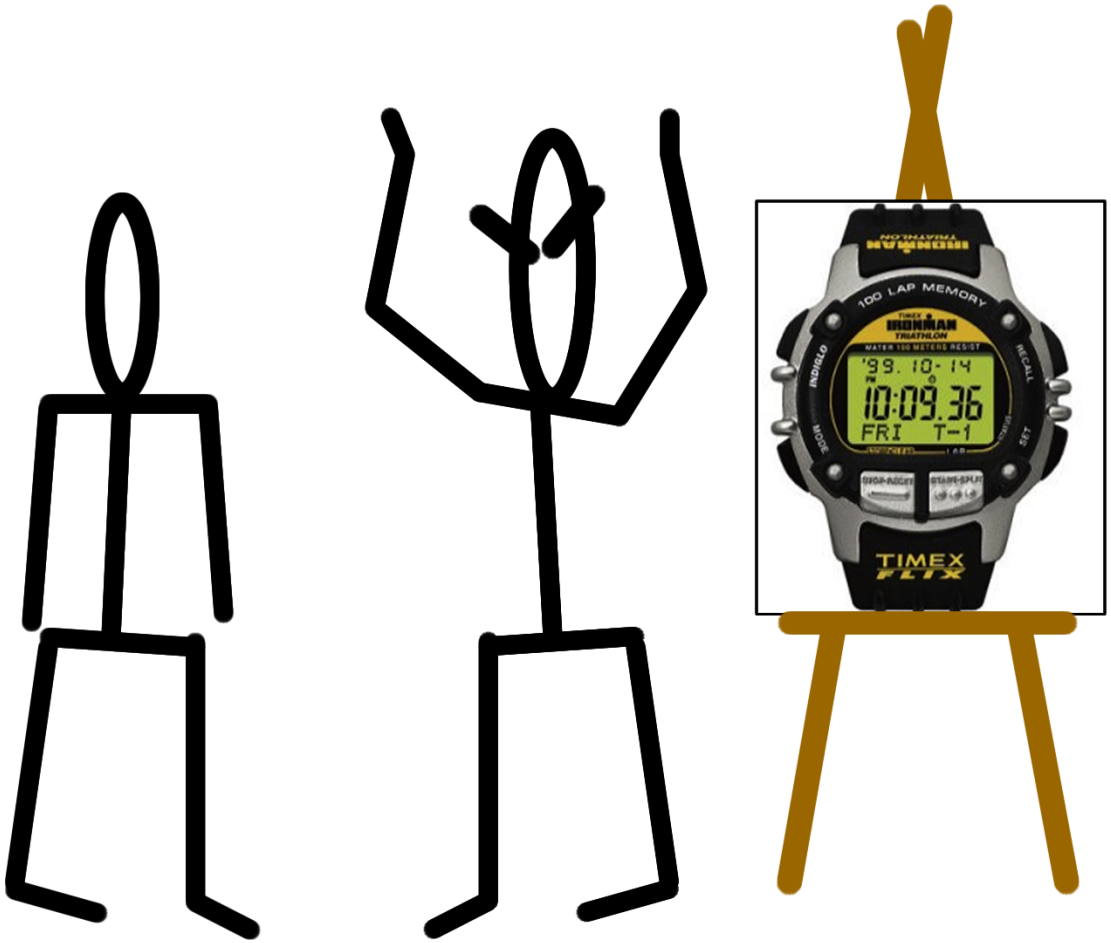


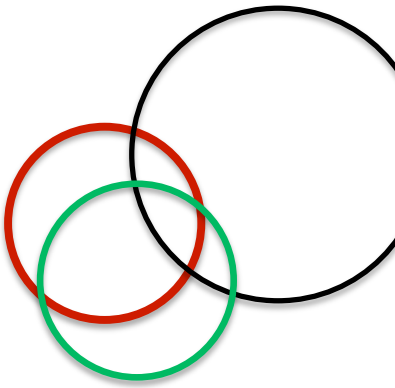
Over-the-wall



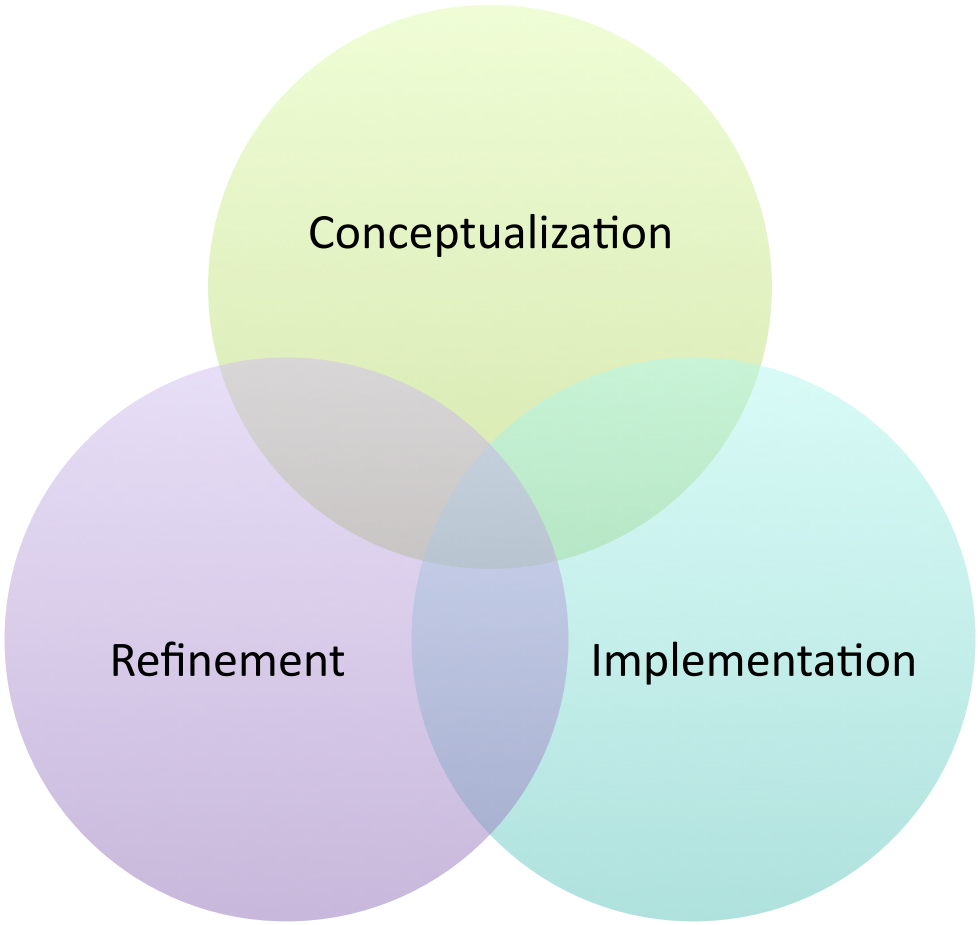
Why doesn’t over the wall work?

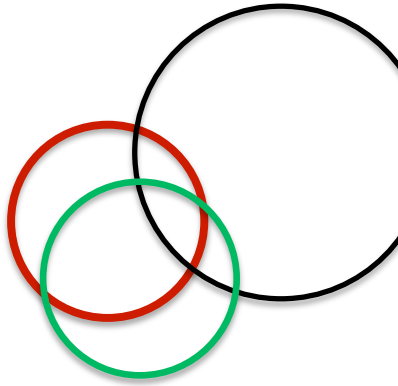
- This is what you get…





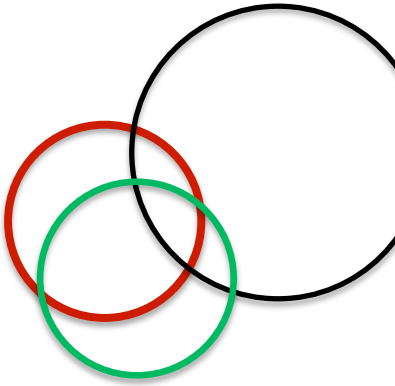
Concurrent engineering





Robotics is not a single-discipline field either

- Mechanical design / mechanisms / manufacturing
  - Mechanical engineering
- Electric circuits / embedded systems
  - Electrical engineering / ECE
- Intelligent behaviors
  - Machine learning
  - Control theory
  - Psychology / cognitive science
- Software development / implementation / machine perception
  - Computer science / ECE



Learning is not a narrow problem

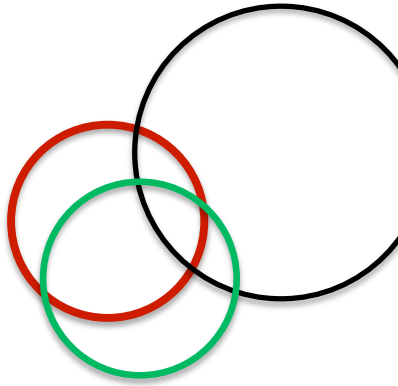
- Psychology
- Computer science & engineering
- Instructional design
- Human-computer interaction
- Linguistics
- Statistics
- Economy
- Machine learning/AI
- Neuroscience
- Education

Small-group discussions: Discuss how your discipline can contribute to your partner's discipline in answering a learning-science problem.

3. HOW CAN WE ENHANCE RESEARCH AND APPLICATION THROUGH INTERDISCIPLINARY WORK?

Beyond the confines

- Not a lack of specific field, rather expansion to incorporate other sources of relevant work
- Example of Javier Movellan / MPLAB and computer vision (CV)
  - Applied machine learning to certain CV problems, and superior to all algorithms within that field
  - Face detection software in Sony cameras – Javier's group's algorithm



Reframing[1]

- Learn to reframe a particular problem in novel ways which elucidate novel paths
- What are all the permutations of what you see below?

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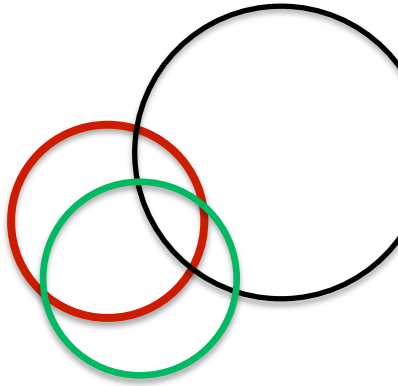

Reframing

- Learn to reframe a particular problem in novel ways which elucidate novel paths

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BUT WHAT ELSE?

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BUT WHAT ELSE?

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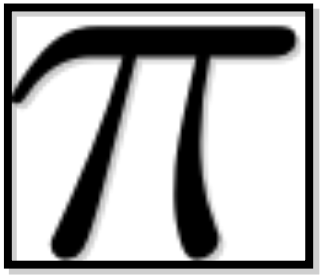
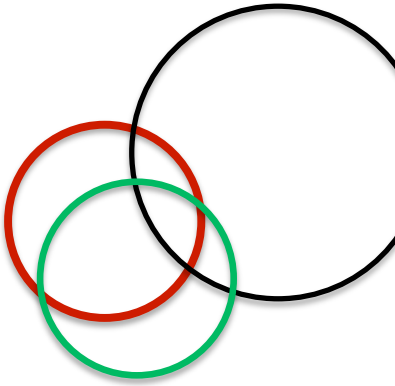
Redefinition

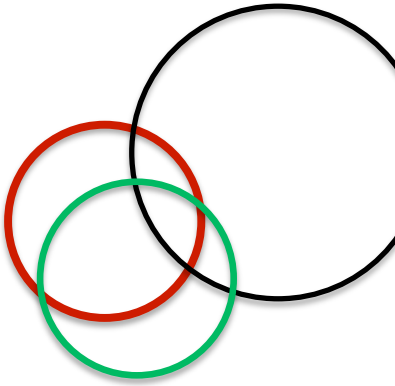
- Example : Equations and variables





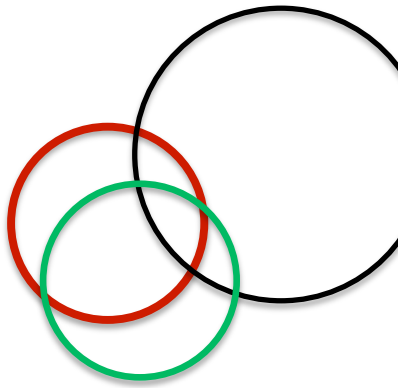
Redefinition

- It can be
  - 3.1415…
  - πύλος
  - The optimal controller
  - Capital pi is sometimes used to denote a product of the elements of (i.e. it is an operator)…
- The word is a pointer to the concept, the discovery
  - “It is like a finger pointing to the moon…don’t just look at the finger or you’ll miss all that heavenly glory…”



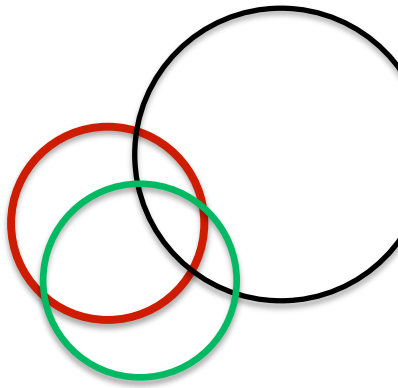
Indirect

- Indirect, out of box thinking
- Persistence of excitation
  - Excitation through disturbance of the norm
- New thinking models/definitions
  - Projection example
    - 3d movies
  - Fields often have different thinking frameworks / models (e.g. machine learning vs. system identification)



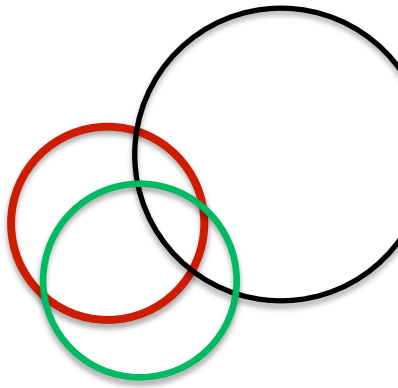
Collaborations

- Large problems where…
  - one framework is too limited, a large group of integrated, multi-faceted frameworks needs to be developed
  - we need to understand causal influences that span across disciplines
  - one perspective is not enough
- Low hanging fruit (and recognition of such)
  - Though participating in multiple disciplines may be challenging, you gain a unique perspective
    - Capitalize on this to recognize solutions to problems
    - Movellan solution



Answering each others' questions

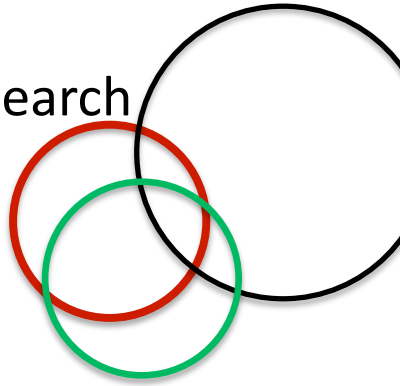
- E*xercise:* Discipline switch
  - Pairs try to understand/explain each other's discipline



4. WHAT CHALLENGES CAN ONE EXPECT TO FACE, AND HOW CAN THEY BE ADDRESSED?

Challenge: Lack of rigor

- Lack of depth and focus
- Common statement – if you work in more than one field you can never achieve any depth because you are distributing your efforts too much
  - There is little support for achievement at a common statement
  - There is an underlying assumption that each branch of research/ interest is independent, which it is not
    - Mutually enhanced
- Recommendations [6]:
  - Specialize within your interdisciplinary research area, don't branch out too much, too fast
  - Build core competencies that sustain interdisciplinary research
  - Attend seminars and courses in other disciplines
  - Reflect on how other disciplines may contribute to core

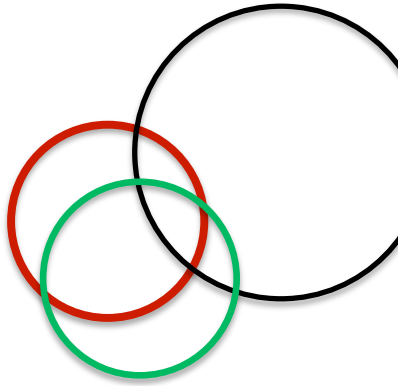


Challenge: Narrowists

- "You should narrow into a tiny branch within a branch within a branch."
- This is one way, and there is room for that too, but as always there are limitations:
  - Disciplinary specialization comes at the cost of fragmented knowledge that does not have a clear relation to realistic problems [14, 15]
  - Disciplinary specialization runs risk of disregarding the broader context of the problems it seeks to investigate [12]
- Recommendations [6]:
  - Don't neglect your disciplinary strengths
  - Try to have at least one publication in each field that you seek to contribute to

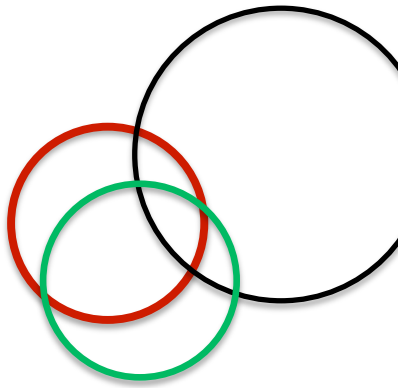
Challenges: Fitting into a department

- Universities tend to be arranged around scholarly disciplines [12]
- During interviews Profs. will be asking you how your work can enhance what they do
  - Too narrow is a problem in such instances
- Recommendations [6, 10]:
  - Apply to multiple possible departments
  - Network with scholars from multiple disciplines (e.g., iSLC)
  - Seek to do excellent work, respect comes sometimes later as a pioneer, but the work speaks for itself [21]
    - "Work hard and do good work!"
  - Explain the relevance of your work w.r.t. disciplines
  - Contextualize your research statement
  - Seek a wide spectrum of reviewers



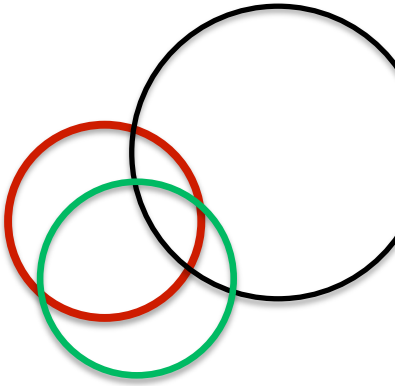
Challenges: discovery

- Mind-set for discovery
- Taking a position that only one's particular field is interested in and shutting off information flow/communication from other areas is a sure way to have a closed mind
  - leads to difficulties because science is about discovery, and discovery is impossible when one's mind is closed.
  - can be in front of your face and you will choose not to see it
- Recommendations [5,12]:
  - Be curious [16]
  - Take a broad perspective [17]
  - Be flexible [17]
  - Beware of your disciplinary blind spots [12]
  - Recognize the limitations of your discipline [18]



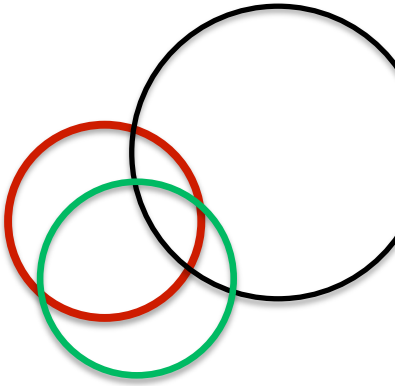
Feedback

- Measurement is possible through difference
- No difference -> no measurement –> no perception
  - Example: experiment with researcher who temporarily paralyzed his eyes, loss of vision (complete gray-out)
  - Example: camouflage
- By interacting with and integrating multiple fields, we incorporate improved feedback as to progress, are we on track, is there a correction we can make to methods to improve them, etc – we create the possibility for measurement



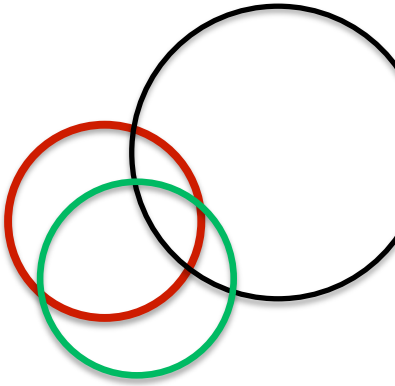
Boundaries

- Wall may exist (field) but be partially transparent/porous
- We need boundaries for fields, otherwise too ubiquitous
  - Publications
- However, we should realize boundaries are useful but are fictitious
  - Even science itself has multiple definitions [20]
  - Many fields have duals, some which are not discovered yet
    - Example : Dual of estimation and control[21]



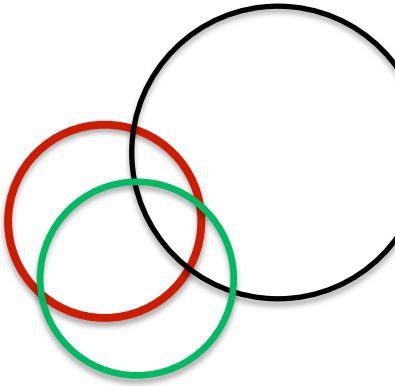
Language

- Different fields may have different ways to refer to things
- Different fields may use the same terms to mean different things
- Examples:
  - “Significance”
  - “Perspective”
  - “Construction”
  - “Attribute”
  - “Science”



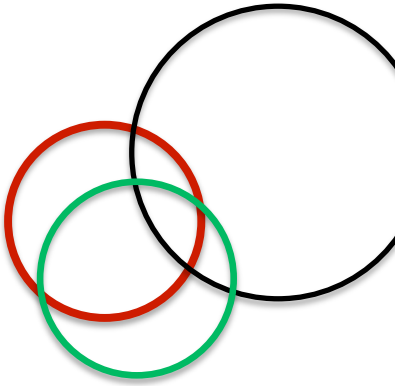
Exercise – Mirroring

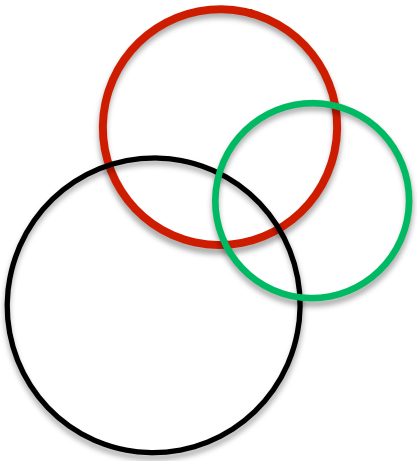
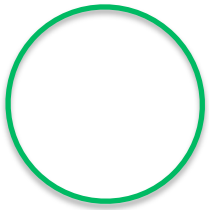
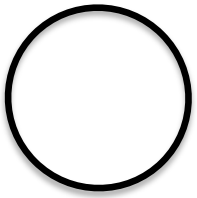
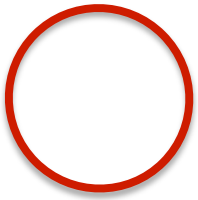
- *Mirroring – follow someone – have to be able to listen (embodied cognition)*
  - *Imagine other person's world*
  - *Reflective*
  - *Not interpret, not filter, not translate*
  - *Before you criticize, understand it from their point of view, then interpret into your view*
  - *Movement exercise can help liberate cognitive faculties*



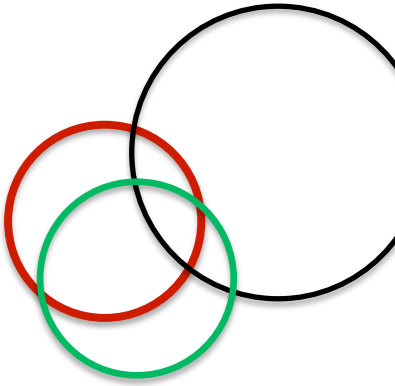
Language strategies

- Reframing
- Dialog
- *Exercise – Chi-sao*
  - *In touch with, aligned with person*
  - *Go along with, follow intention*
    - *If aggressive, lead to safe place*
    - *In one the action, the other the attention*
    - *More sophisticated*



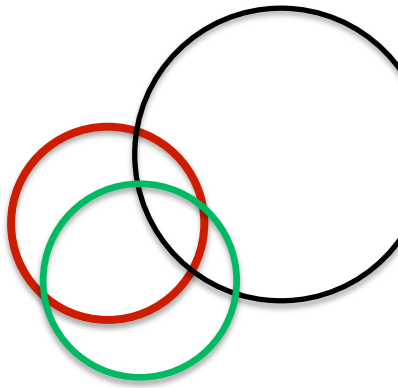





5. CONCLUSIONS AND RECAP



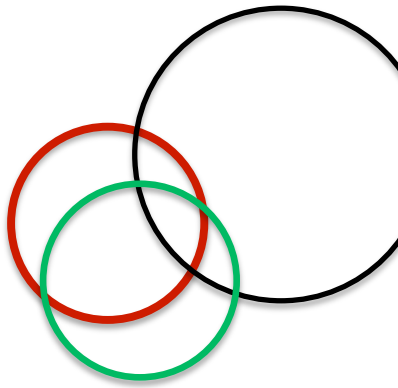
Conclusion

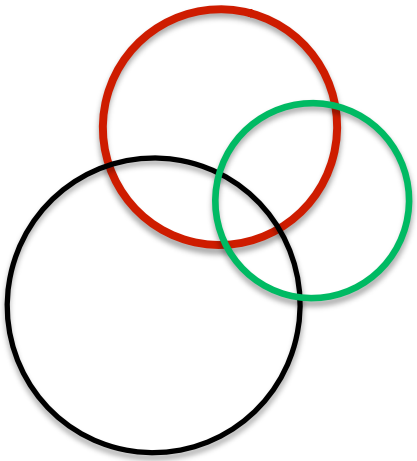
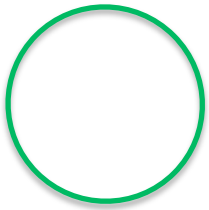
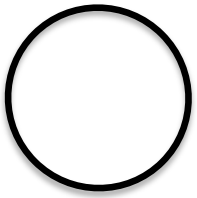
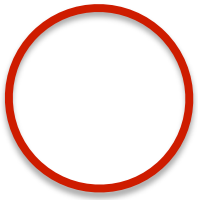
- Historically, many successful people who made excellent contributions, and the founders themselves
- Some argue narrowness, but engineering shown concurrent engineering method more effective for solving real problems
- Wall may exist (field) but be partially transparent/porous – too much lack of definition not good, need substance to branch from
- Not *no* field, just beyond confines of field



Conclusion

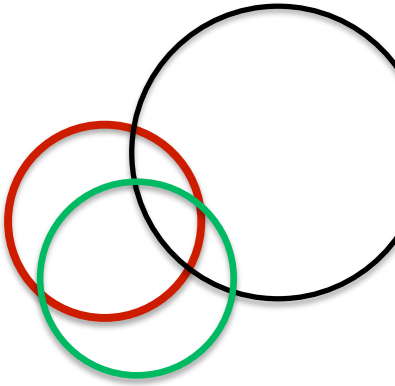
- Fitting in department
  - Actually you can fit into more than a single department/any
  - And you can enhance others' work more effectively
- New thinking models/definitions
- Pluralism, whatever works well has a place vs. grand unifying theory



QUESTIONS AND DISCUSSION

(and thank you!)



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