School of Computer Science Overview

15-110 – Friday 12/09

Announcements

- Congratulations on finishing Hw6!

- Reminder: Final Exam is **Friday 12/16 1-4pm**
  - We'll do a Piazza post with more details soon

- We would appreciate it if you filled out end-of-semester surveys to let us know how the class went.
  - FCEs for instructors & the class in general: https://cmu.smartevals.com
  - SCS form for TAs: https://www.ugrad.cs.cmu.edu/ta/F22/feedback/
  - 15-110 Post-Semester Survey: https://bit.ly/110-f22-post
    - Fill this out by Monday 12/19 at noon to get 1 bonus points on Hw6!

Learning Objectives

- Recognize the **seven departments** in the School of Computer Science (SCS)
- Understand how each department's work **interprets** computer science
- Identify ways to learn more in each department through available **courses** and **majors/minors**

Overview

SCS History

Original computer science work was done through math/engineering departments, starting as early as 1956

SCS was officially founded in 1988

Arguably the first college dedicated to computer science in the United States

Read more: https://www.cs.cmu.edu/scs25/history

SCS Today

283 faculty members, 1663 graduate students, 984 undergraduate students

Seven departments: CSD, RI, LTI, HCII, MLD, S3D, and CBD

Four undergraduate majors, and minors in all departments

Learn More in SCS

- B.S. in Artificial Intelligence
- Minor in Neural Computation [managed by Neuroscience Institute]

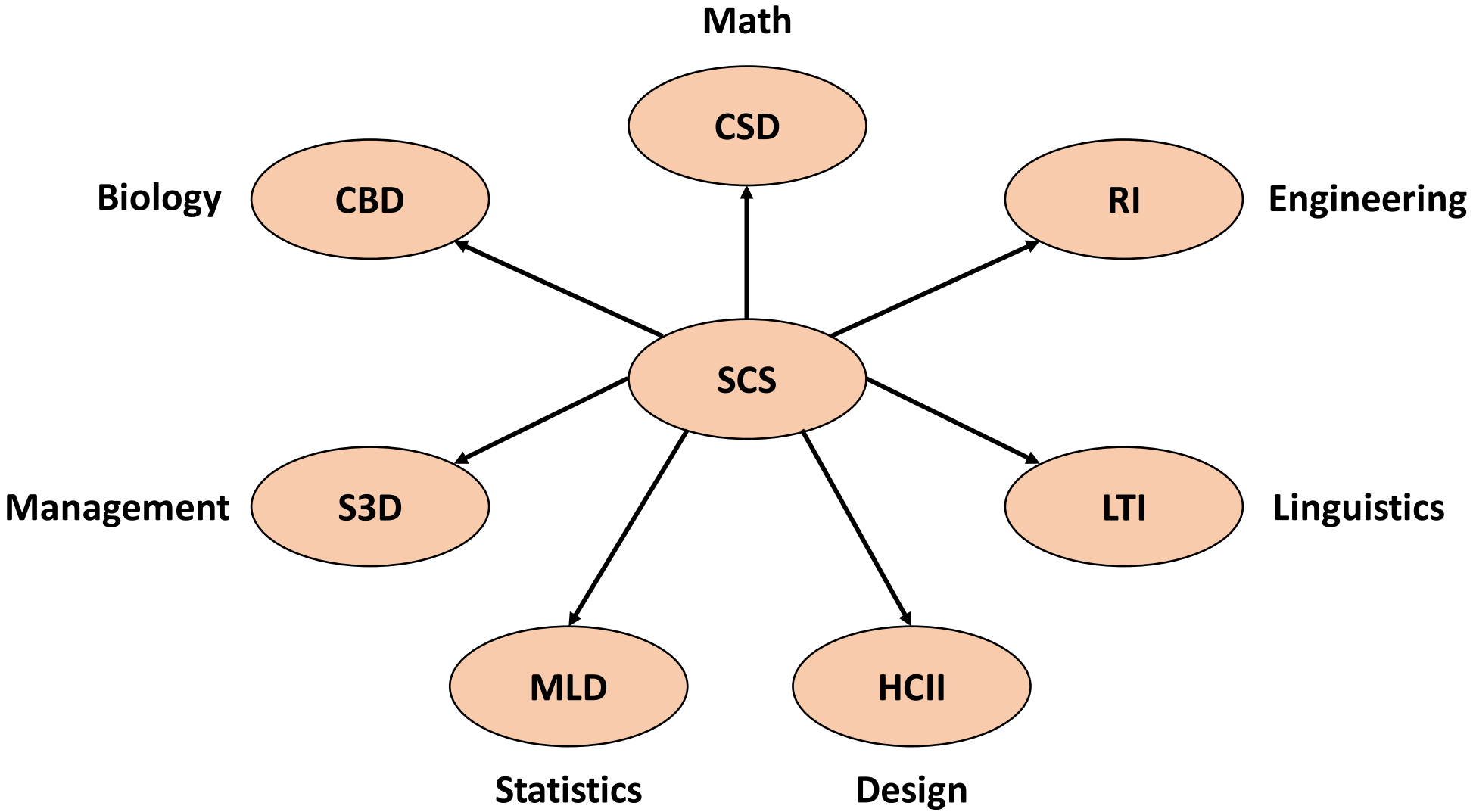
IDEATE: Technology, Design and Arts Study

Offers Minors in:

- Game Design
- Animation and Special Effects
- Design for Learning Media
- Media Design
- Sonic Arts
- Innovation and Entrepreneurship
- Intelligent Environments
- Physical Computing

Course list here

SCS Departments



Computer Science Department (CSD)

CSD Purpose

CSD forms the core of the School of Computer Science. It was the first department founded (in 1965 within MCS), is the largest of the departments, and does most of the undergraduate teaching.

Research and academics in CSD are centered around the core concepts of computer science: algorithms and abstraction. Research is often done through math and logic, by proving certain computational properties.

CSD also acts as a catch-all for topics that don't fit into the other departments.

Major Research Areas in CSD

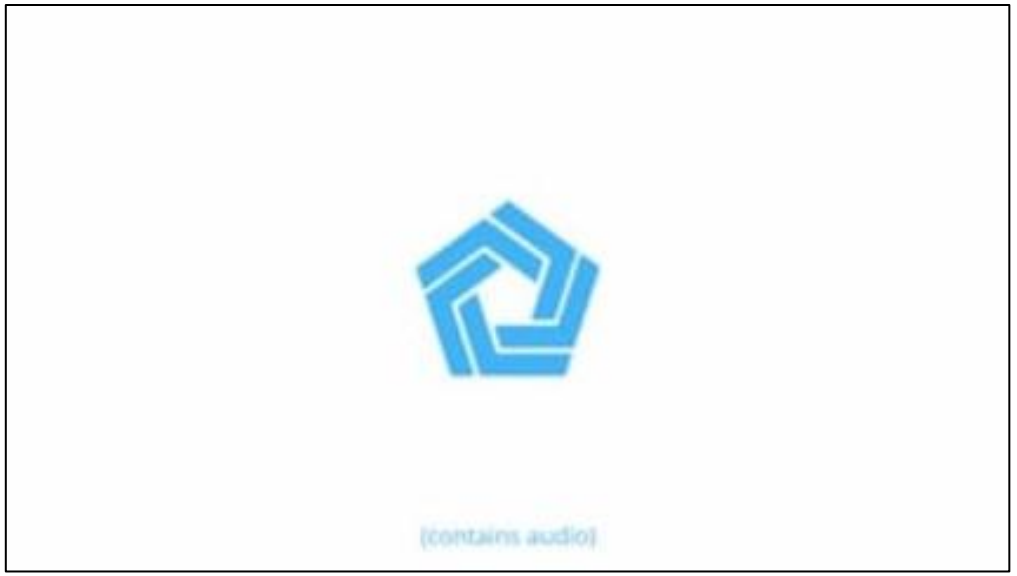
Currently, CSD focuses on a collection of core topics:

- **Theory:** the study of algorithms, both their design and complexity
  - Lots of theorem-proving and math
- **Programming Languages (PL):** theory and applications of programming languages
  - Lots of theorem-proving, but also development of new languages
- **Artificial Intelligence (AI):** the study of how to make computers act 'intelligent'
  - Has deep connections with the Machine Learning Department
- **Systems:** the study of how hardware and software work together at scale
  - Often done through building example systems to prove a concept
- **Security:** the study of security and privacy in computer systems
  - Finds flaws in current systems, and designs provably-secure new systems
- Also a group that studies **Graphics**, how to program computer graphics

CSD Research Examples

[An AI that learned to play Texas Hold'em and beat professional players at it]

[Automatically translate math into figures and pictures]



Learn More in CSD

- B.S. in Computer Science
- Additional Major in Computer Science

- Bachelor of Computer Science and Arts
- B.S. in Music and Technology

- Minor in Computer Science

- SCS4All

Next Courses:

- 15-112: Fundamentals of Programming and Computer Science
- 15-122: Principles of Imperative Computation

Take for fun:

- 15-292: History of Computing
- 15-294: Rapid Prototyping Technologies [requires 112]
- 15-386: Neural Computation [requires 112]
- 15-390: Entrepreneurship for Computer Science

Robotics Institute (RI)

Robotics Purpose

The Robotics Institute is the engineering arm of SCS. It studies robots, both theoretical (through algorithm design) and practical (by actually building machines).

A robot is a programmable machine that can perform actions on its own. Robots range widely in what they look like and how they work.

RI was founded in 1979 in a collaboration between CSD, MCS, and CIT.

Learn more: https://www.ri.cmu.edu/about/ri-history/

Stack of Robotics Research

Research into robotics can be viewed as a stack, from the seemingly simple to the complex.

Action: how to control a robotic component, make it do a thing

Perception: how a robot can understand its environment

Learning: determining what to do based on environment

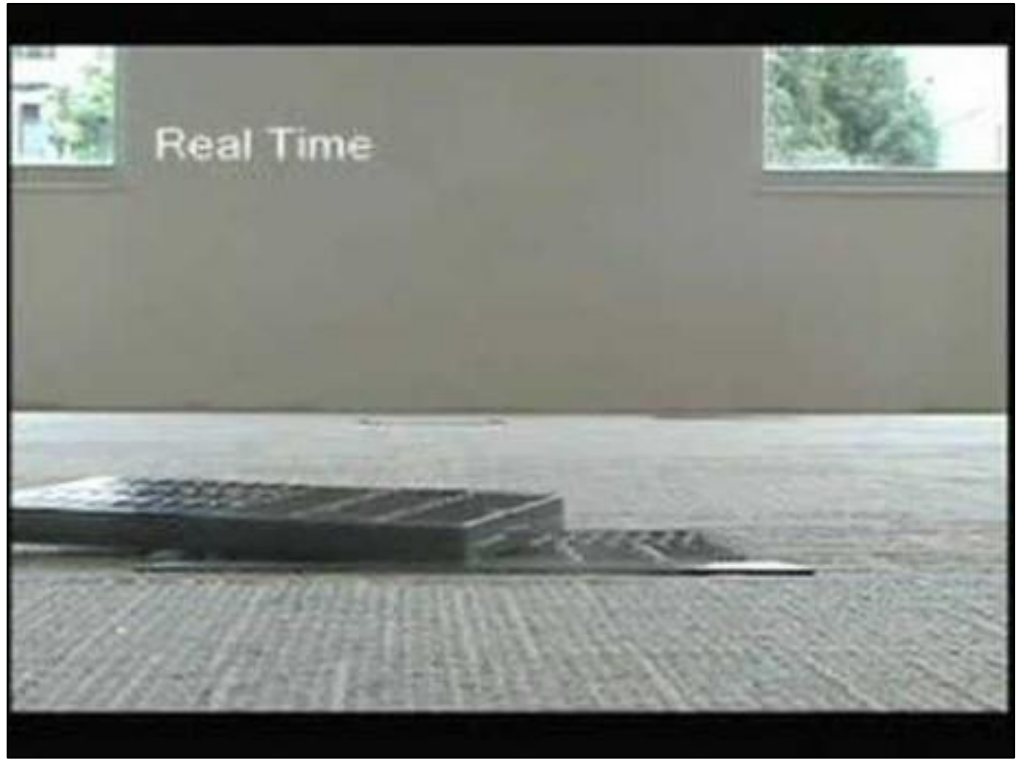
Autonomy: after being given a goal, accomplish the goal independently

Human Interaction: interact with human beings fluidly

RI research covers a range of topics that range from theoretical to practical. In addition to the ideas mentioned above, RI also studies **Field & Service Robotics** (how to design robots for outside environments) and **Robot Structures** (how to manufacture hardware).

RI Research Examples

[Modular Snake Robot]



[Using Multiple Cameras to Edit Videos]

Learn More in RI

- Additional Major in Robotics
- Minor in Robotics
- CMU Robotics Club

First course:

- 16-311: Introduction to Robotics

Take for fun:

- 16-223: Creative Kinetic Systems
- 16-264: Humanoids
- 16-467: Human Robot Interaction

Language Technologies Institute (LTI)

LTI Purpose

The Language Technologies Institute focuses on how algorithms can understand, use, and interact with human language via audio or text. This incorporates ideas from linguistics and machine learning.

LTI started as the Center for Machine Translation, which was founded in 1986. The Center joined SCS when the school was founded in 1988, then was upgraded to department status in 1996 after adding a PhD degree option.

Major Research Areas in LTI

Language Technologies breaks down into many topics. Here are the core ones:

Middleware Technologies: the core components of linguistic analysis, including speech recognition, information retrieval, and natural language processing

Focused Application Areas: designing LTI for specific purposes, including text mining, data mining, and spoken interfaces

Enabling Science and Technology: includes linguistics analysis, signal processing, and large-scale computing

LTI Research Examples

Automatic detection of positive comments amidst hate speech in social media

Designing good final lines in automated storytelling

Learn More in LTI

- Minor in Language Technologies

First course:

- 11-324: Human Language for Artificial Intelligence

Take for fun:

- 11-344: Machine Learning in Practice
- 11-423: Conlanging
- 11-485: Introduction to Deep Learning [requires 112]
- 11-488: Computational Forensics and AI

Human-Computer Interaction Institute (HCII)

HCII Purpose

Human-computer interaction is the study of how people interact with computational devices, and how computers integrate into society.

This is done through a mix of computer science, design, and psychology. This means HCI methods range from technical to interviews and paper prototypes.

The Human-Computer Interaction Institute was founded in 1993 by faculty across several departments.

Learn more: https://www.hcii.cmu.edu/news/2019/celebrating-25-years-hcii

Major Research Areas in HCII

HCI research can be roughly organized into three groups:

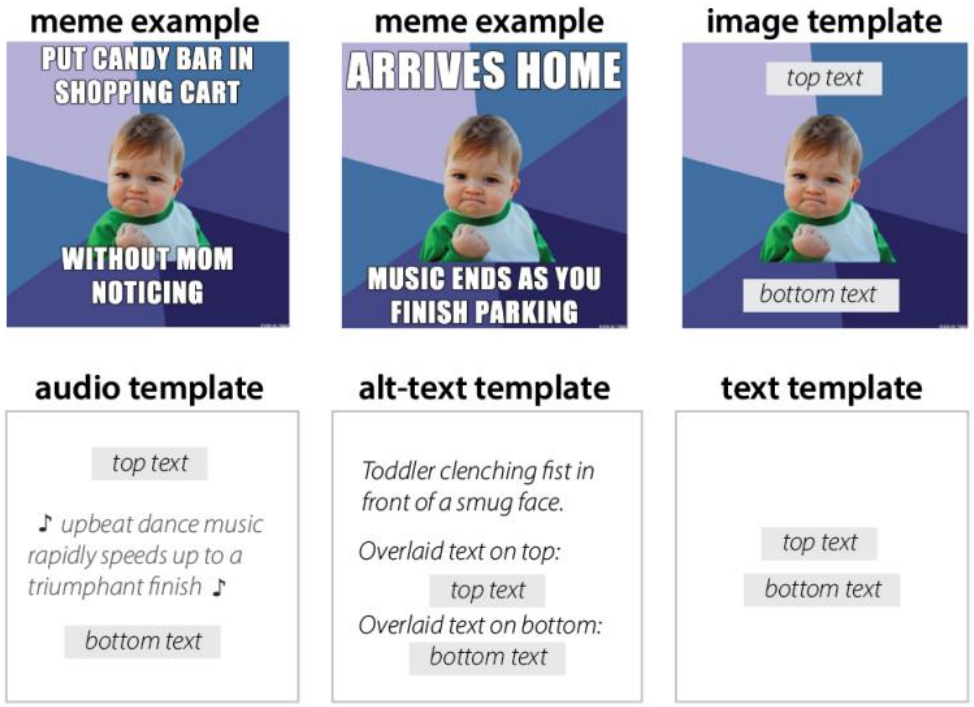
- **Technical:** research that builds new hardware or software to expand how people can interact with technology. Includes wearables, context-aware computing, and enabling technologies.
- **Behavioral:** research that investigates how humans interact with other humans through technology, or with technology directly. Includes social computing, crowdsourcing, and human-robot interaction.
- **Design:** research that investigates how technologies and services are created and how they should be structured to support people's needs. Includes user experience design, service design, and prototyping methods.

HCII also does more application-based research into educational technology, healthcare technology, and games.

HCII Research Examples

[VR where you can touch objects and 'feel' them]

[Making memes accessible for people who are visually impaired]



Learn More in HCII

- B.S. in Human-Computer Interaction
- Additional Major in Interdisciplinary Human-Computer Interaction

- Minor in Interdisciplinary Human-Computer Interaction

First course:

- 05-391: Designing Human Centered Software

Take for fun:

- 05-318: Human AI Interaction
- 05-333: Gadgets, Sensors and Activity Recognition in HCI
- 05-392: Interaction Design Overview
- 05-418: Design of Educational Games
- 05-432: Personalized Online Learning

Machine Learning Department (MLD)

MLD Purpose

The Machine Learning Department studies the theory and implementation of machine learning. This is a branch of computer science that studies how algorithms can find patterns in data to learn and improve over time.

ML draws from the field of statistics in addition to computer science, both to build new algorithms and test learning capability.

MLD started as the Center for Automated Learning and Discovery in 1997 and was promoted to department status in 2006.

Learn more: https://www.ml.cmu.edu/about/

Major Research Areas in MLD

Research done in the department clusters around several vectors:

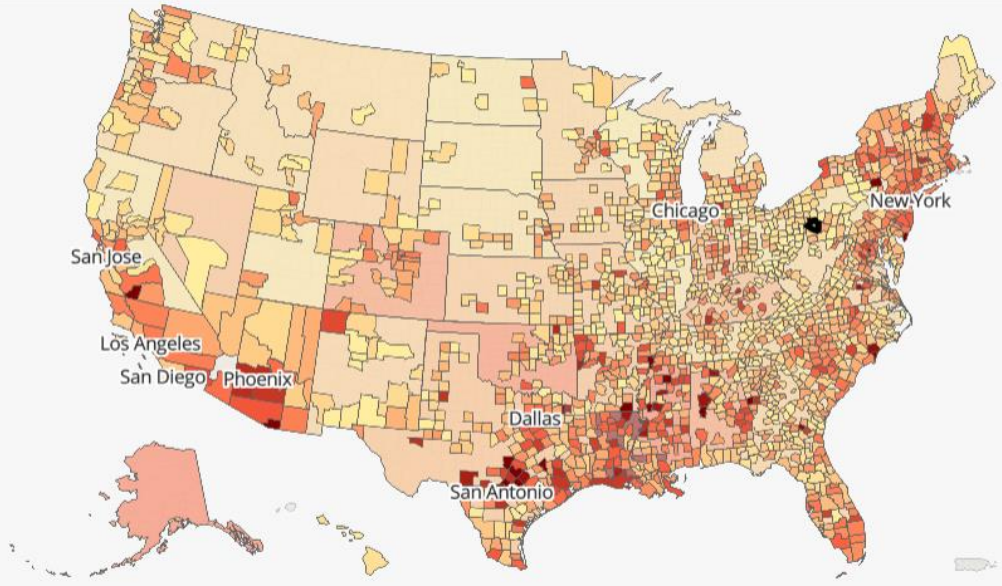
Theory: this is the core of machine learning, trying to prove things about algorithms (like efficiency or feasibility) and address ideas such as fairness and accountability.

Medium: what types of data can ML act on? Especially language (with LTI) and vision (with Robotics)

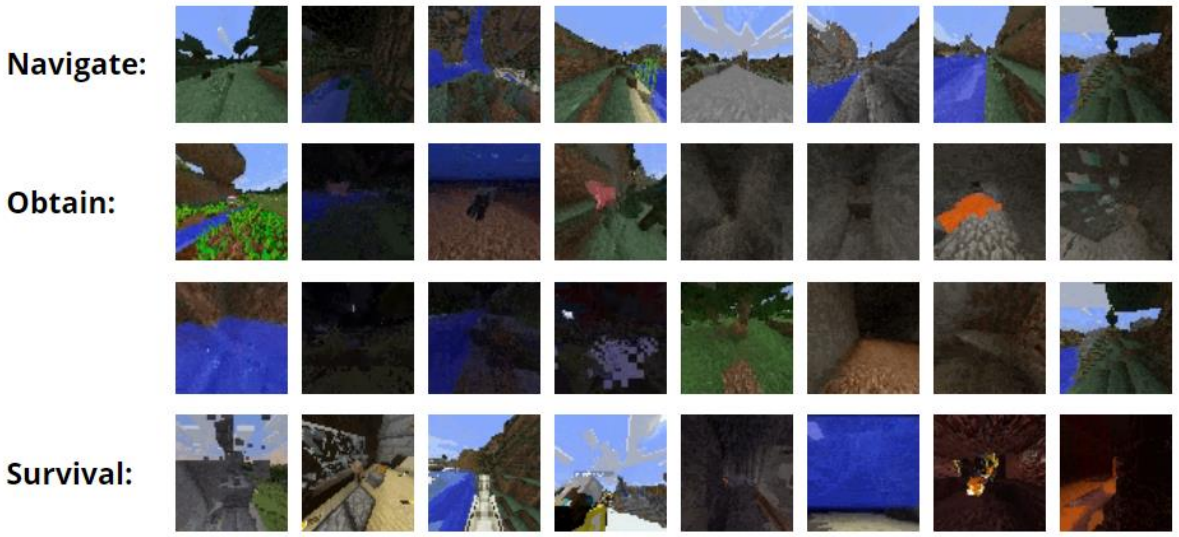
Application: where can ML support other fields? They've worked in business, science, health, biology, logistics, and more

MLD Research Examples

COVID-19 forecaster



Training AIs to mine diamonds in Minecraft



Learn More in MLD

- B.S. in Statistics and Machine Learning [managed by Dietrich]
- Minor in Machine Learning

First course:

- 10-301: Introduction to Machine Learning [requires 122]

Take for fun:

- 10-403: Deep Reinforcement Learning & Control [requires 10-301]
- 10-417: Intermediate Deep Learning [requires 10-301]
- Most MLD classes are graduate level.

Software and Societal Systems Department (S3D)

Formally known as the Institute for Software Research (ISR)

S3D Purpose

The Software and Societal Systems Department studies software engineering, the process of how complex software is developed and used by large teams of people.

This department has the closest connection to industry, as software engineering is how computer science is implemented at scale, in tech companies. This means that much of the work in S3D can be viewed through a management lens.

S3D was founded in 1999, as a department in SCS.

Major Research Areas in S3D

S3D's main research topics can be roughly divided into two groups:

Software Engineering

- **Software Architecture:** the design and organization of complex code projects
- **Software Assurance:** how to make sure that code does what it's supposed to
- **Program Analysis:** automatic analysis and modification of code to improve it
- **Cyber-Physical Systems:** computer systems that have physical parts in the process
- **Big Data:** the study of how to store and work with exceptionally large datasets

Societal Computing

- **Socio-Technical Systems:** the design and organization of how humans interact with computers and software at large scale
- **Security and Privacy:** how people and companies protect and share data

S3D Research Examples

Automatically rating apps for privacy policy compliance

Detecting disinformation on social networks

Automatically finding and repairing bugs

Learn More in S3D

- Minor in Software Engineering

First course:

- 17-313: Foundations of Software Engineering

Take for fun:

- 17-214: Principles of Software Construction: Objects, Design, and Concurrency [requires 122]
- 17-303: Cryptocurrencies, Blockchains and Applications
- 17-333: Privacy Policy, Law, and Technology
- 17-334: Usable Privacy and Security

Computational Biology Department (CBD)

CBD Purpose

The Computational Biology Department studies problems in the field of biology through a computational lens. These algorithms can help give insights into biological systems, which leads to the design of new experiments.

CMU first offered degrees in computational biology in 1989; this eventually led to the creation of the Center for Computational Biology in 2007. The center was upgraded to department status in 2009, and is the youngest of the seven SCS departments.

Learn more: http://cbd.cmu.edu/about-us/timeline.html

Major Research Areas in CBD

Most research in CBD centers around developing **models,** finding new directions for **scientific research,** and **optimizing** studies. Their research also clusters around topics like:

- **Genetic bases of complex diseases**
- **Evolutionary biology**
- **Sequence analysis**
- **Computational models of cells and tissues**

CBD Research Examples

Automatically identifying potential antibiotics in microbial genes

Identifying Brain Cells Associated with Parkinson's

Learn More in CBD

- B.S. in Computational Biology
- Additional Major in Computational Biology
- Minor in Computational Biology
- Computational Biology Society
- Take a free online course on COVID-19

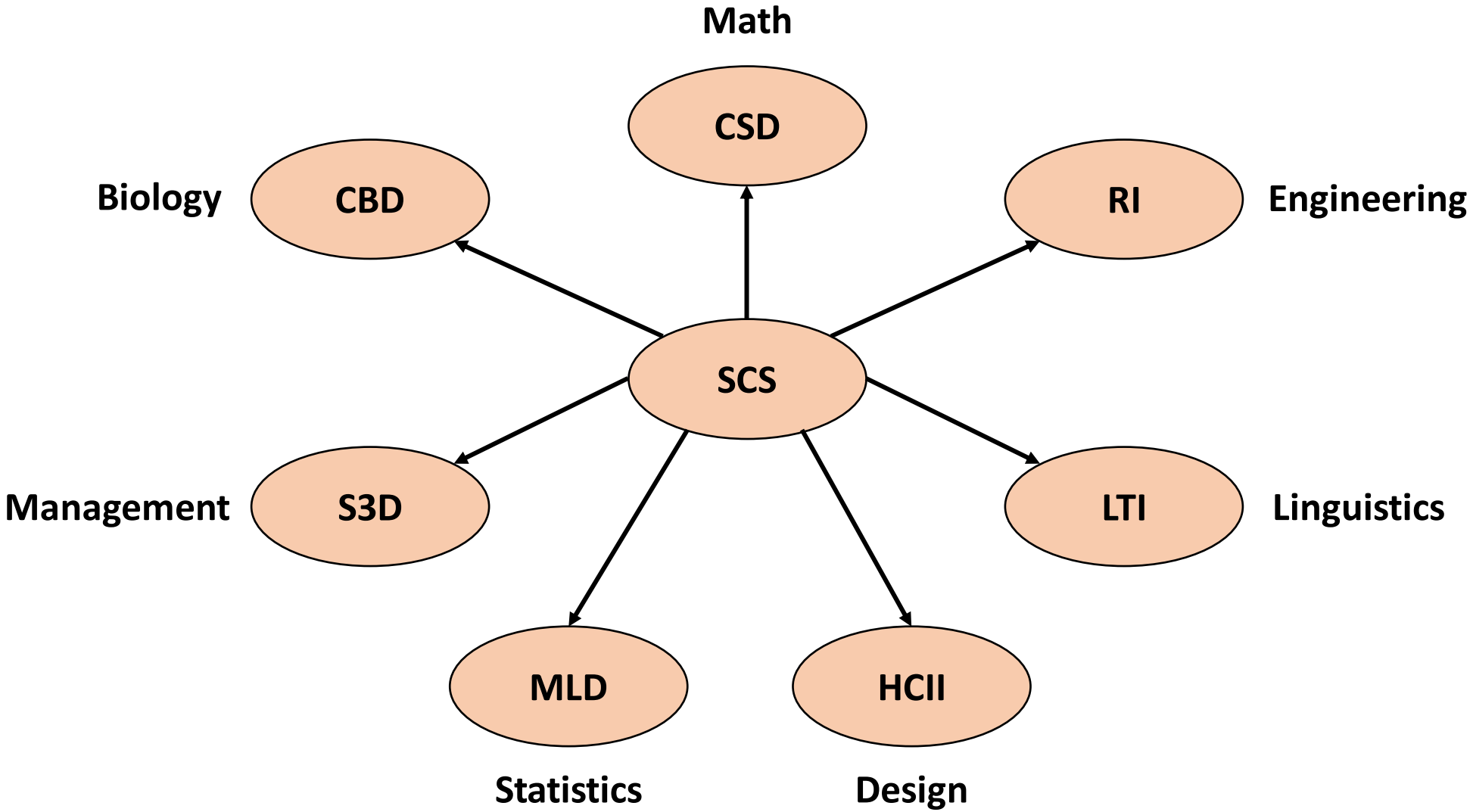
First course:

- 02-250: Introduction to Computational Biology [requires 112]

Take for fun:

- 02-261: Quantitative Cell and Molecular Biology Laboratory
- 02-319: Genomics and Epigenetics of the Brain
- 02-331: Modeling Evolution [requires 112]

SCS Departments



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