School of Computer Science Overview

Kelly Rivers

Learning Goals

- Recognize the seven departments in the School of Computer Science (SCS)

- Understand how each department's work interprets computer science

- Recognize popular projects that originated in each of the seven departments

About Me

2007-2011: CMU undergraduate student

- Math & Computer Science double major
- TA for 15-112 equivalent

2011-2017: CMU graduate student

- Human-Computer Interaction
- Studied Learning Science/Educational Technology

2017-present: CMU Assistant Teaching Professor

- Computer Science Department
- Taught 15-112 for two years and 15-110 for one year

Overview

What is Computer Science?

Programming: the act of giving instructions to a computer. Done with programming languages, like Python/Go.

Algorithms: procedures that specify how to do a needed task or solve a problem. Instantiated in programs.

Computer Science: the study of algorithms, abstraction, and implementation. Covers a wide range of subfields!
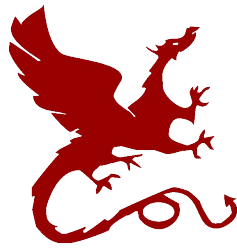
SCS History

Original computer science work was done through math/engineering departments

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, 1606 graduate students, 854 undergraduate students

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

Undergraduate majors in Computer Science, Artificial Intelligence, Computational Biology, and Human-Computer Interaction

Undergraduate minors in all seven departments

SCS Departments
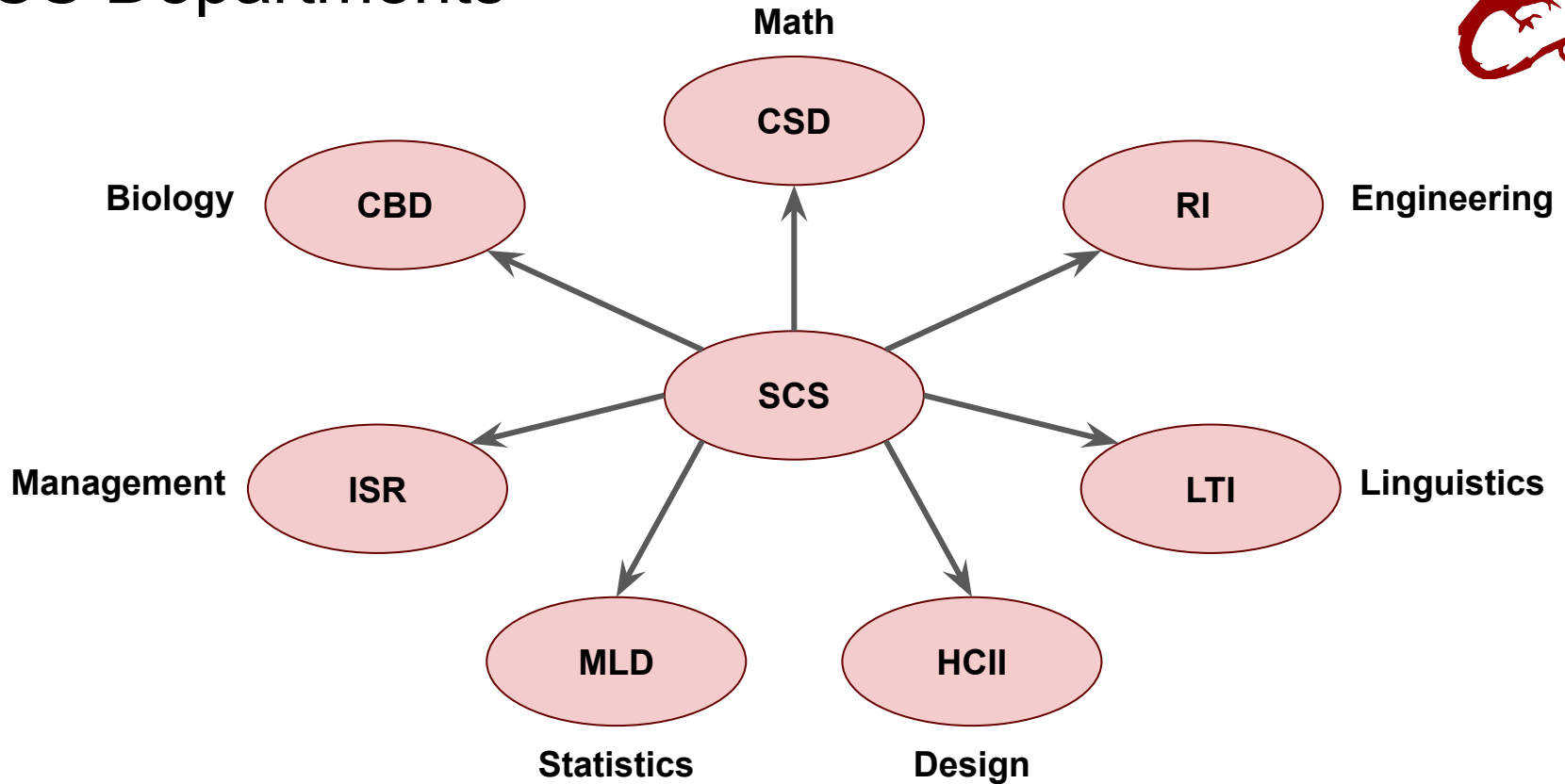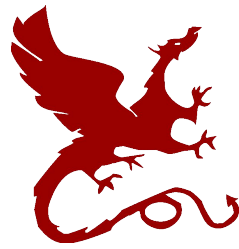
Computer Science Department (CSD)

CSD Purpose

CSD forms the core of the School of Computer Science. It was the first department founded, 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.

Founding history

Carnegie Mellon started studies in computer science in 1956.

The first computer in CMU was an IBM 650- see right.

The Computer Science Department was created in 1965, within the Mellon College of Science.

Learn more: https://csd.cmu.edu/mission-history

Major research areas

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 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](#)

Video: https://vimeo.com/416822487

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 with collaboration between CSD, MCS, and CIT.

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

Major Research Areas

RI research covers [a range of topics](#) that range from theoretical to practical:

- **Robotics Foundations:** underlying algorithms that make robots work
- **Sensing & Perception:** how to gather input information from the world
- **Manipulation & Interfaces:** using that information to interact with the world
- **Robot Structures:** building the physical components of robots

The department also focuses on more applied aspects of robotics:

- **Field & Service Robotics:** how to design robots for specific environments
- **Human-Centered Robotics:** how to design robots that interact with people
- **Graphics & Creative Tools:** how to use robotics theory in non-robot tasks

RI Research Examples

[Modular Snake Robot](#)
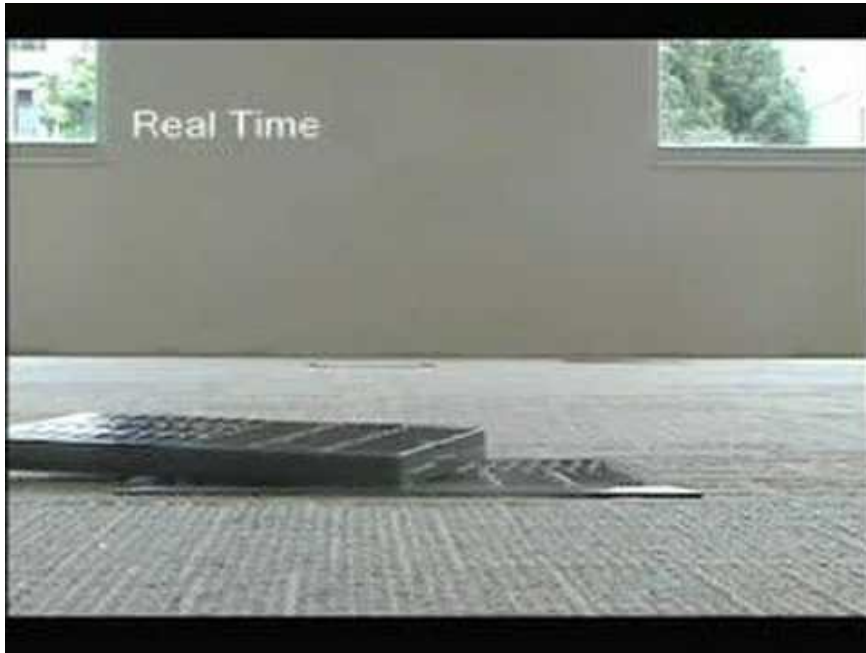
[Improving self-driving cars with empty space recognition](#)

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, and was upgraded to department status in 1996 after adding a PhD degree option.

Major Research Areas

Language Technologies breaks down into [many topics](). Here are the core ones:

- **Speech Processing** attempts to identify the language in audio recordings. **Spoken Interfaces** are systems that support this processing.
- **Natural Language Processing** breaks text down into parts, to identify more structured meaning.
- **Information Retrieval** and **Information Extraction** attempt to find sought information in unstructured documents and return it in a structured format.

LTI also does more applied work with LTI, including **multimodal computing,** the study of how to support real-world communication with computers, and **educational technology,** using language to support learning.

LTI Research Examples

Automatic detection of positive comments amidst hate speech in social media

Designing good final lines in automated storytelling

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

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

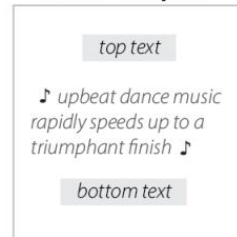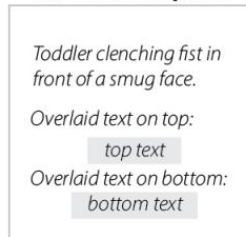Making memes accessible for people who are visually impaired

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

The research in MLD varies greatly depending on what kind of data is being used, and what the purpose of an algorithm is. But topics share some commonalities:

- **Optimization:** how to automatically improve an algorithm's performance on future datasets
- **Parameterization:** how to choose which features are used in a model to make predictions
- **Planning:** after training a model on data, deciding what an AI should do when new data is inputted
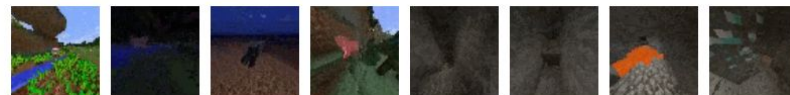
MLD Research Examples

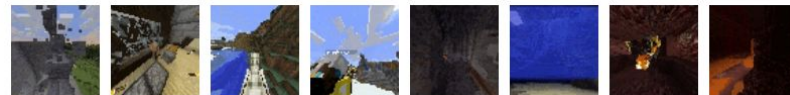COVID-19 forecaster
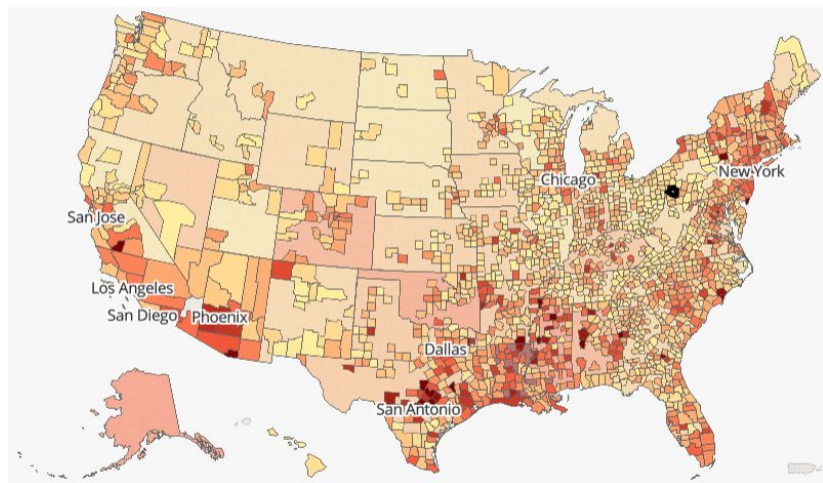
Training AIs to mine diamonds in Minecraft

Institute for Software Research (ISR)

ISR Purpose

The Institute for Software Research 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 ISR can be viewed through a management lens.

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

Major Research Areas

ISR'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

ISR Research Examples

Automatically rating apps for privacy policy compliance

Detecting disinformation on social networks

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://www.cbd.cmu.edu/about-us/history/

Major Research Areas

Like MLD, CBD's research varies based on the problem being studied. Three themes that exist across projects include:

- **Automated Discovery:** the use of AI to find patterns in data and suggest experiments
- **Big Data Integration:** methods to combine datasets from different contexts, to support further analysis
- **Genetic Sequencing:** methods to identify meaning in DNA and RNA data
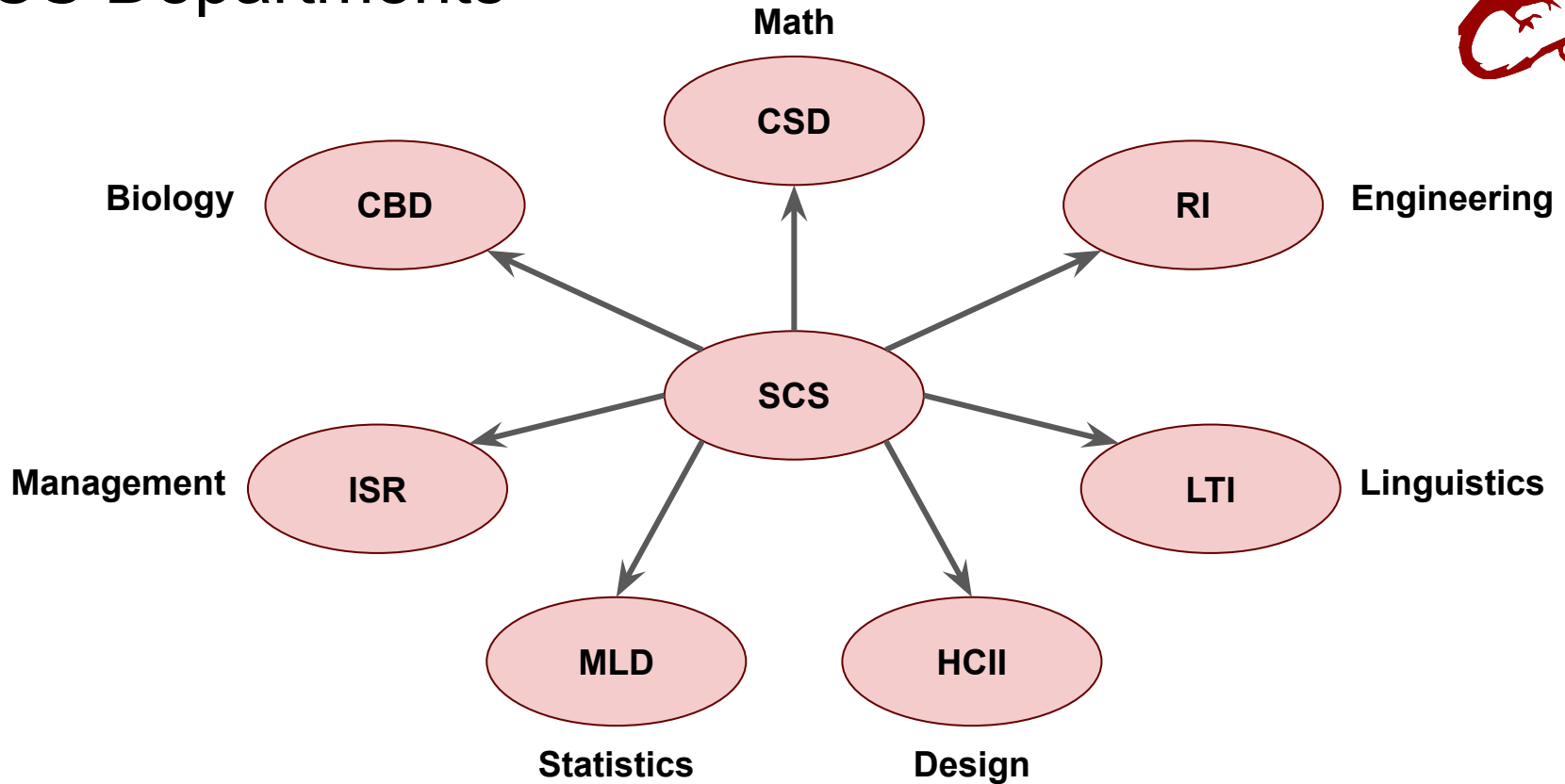
CBD Research Examples

[Automatically identifying potential antibiotics in microbial genes](#)

[More accurate assembly of RNA transcripts](#)

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