Data/Network Science

Electrical & Computer Engineering







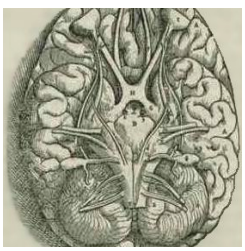
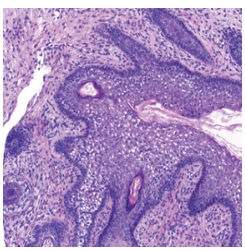
The last few years have witnessed a data explosion in volume, rate, and diversity; this data deluge has been facilitated by computing, communication, electronics integration and miniaturization, and storage technologies.

Data arises in practically every application domain: from the physical to the social; from health industries to the corporate world; in the experiments of particle physics like the Large Hadron Collider in CERN or in surveying the sky with the Hubble Space Telescope; in a metropolis such as New York City detailing the 190 million taxi rides in 2010, the 1.7 billion passenger trips in 2013, or the yearly 11 million 911 calls, or videos collected by the 400 cameras that survey as many intersections; in every call made by a cell phone user that can track mobility, or the patterns in every tweet and retweeted; in entertainment programs; in the many offerings of service industries; data from the multitude of sensors that instrument shopping centers, airports, cities, and industrial or educational campuses; in businesses, retailers, organizations; in every item bought by every customer in every supermarket of every U.S. city; in medical records in hospitals and doctors' offices; in each human's genome.

Data is *diverse* in nature: alphanumerical, categorical, symbolic, sound, images, visual, text, contextual, biological, chemical, or social. Data is *distributed*: it is acquired, measured, stored, and consumed in many scattered ways.

Data is *relevant:* it serves a purpose, illuminates with new insights a meaningful application, leads to timely action, or helps prevent undesirable outcomes before the fact.

Big Data is a game changer – the confluence of a perfect storm of enabling technologies of the last five years. The 40 ZB (1ZB = 10^{21} bytes) of data to be generated yearly by the end of the decade is an inflection point. Our challenge is to maximize its transparent, efficient, and easy use and utility to the end users. There are educational and research opportunities for developing methodologies for acquiring, storing, computing, accessing, transmitting, securing, ensuring safety and privacy, managing, analyzing, actuating, decision making, knowledge extraction, and policy making; all these opportunities are informed by a diversity of applications in critical domains, spanning from nano to macro scales.

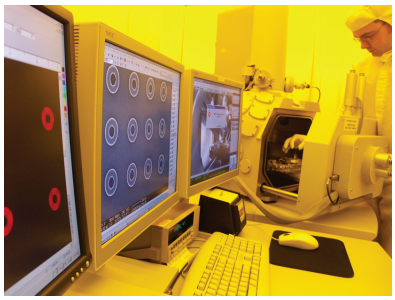

Electrical & Computer ENGINEERING

Carnegie Mellon University
5000 Forbes Avenue | Pittsburgh, PA 15213 | www.ece.cmu.edu

ECE expertise

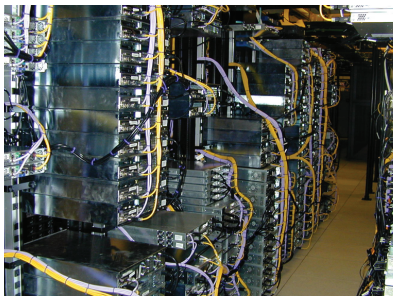
ECE contributes key expertise to the challenges arising from this downpour of data; it leverages on the strengths available across CMU in a number of on-going and planned initiatives, including the Simon Initiative, the BrainHub, the Scott Energy Institute, and Metro-21.

Circuits and devices for data acquisition, storage, and sensing



Ubiquitous sensing and the instrumenting of the Internet of Things requires smart sensors that combine new devices, circuits and MEMS for energy efficient data acquisition and localized information processing. Our research spans from sensor hardware, such as MEMS neural probes, to materials and devices for non-volatile nanoscale storage, to integrated circuits that are based on co-design of algorithms and logic-in-memory architectures. *Contact: Larry Pileggi.*

Computer systems and networking

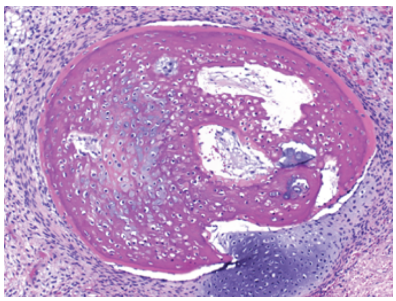


Mining new types of data sets, such as live feeds (e.g. video or Twitter) will require computing environments with parallel architectures for managing storage and retrieval among computing servers in conjunction with parallel programming to deliver task-specific code that will satisfy the needs of algorithms used for analysis, an area in which ECE researchers have already made fundamental contributions. Furthermore, transmitting data and giving users easy access requires management of pervasive network centers switching the Internet traffic, from local to wide areas, to the cloud. ECE faculty have had a leading role from designing the architecture of the future Internet, to fast optical switches, to managing complexity in network switching centers. *Contact: Greg Ganger.*

Security and privacy

Data is massive and personal; it records private details of individuals and their daily lives. Cameras instrument public spaces, and the ubiquitous cell phone is not just a smart platform but also an ambulant sensing and recording device that stores copious details of our goings about. Privacy is a major concern, and requires the development of tools from those confirming that companies' complex software systems deliver promised privacy guarantees to methodologies that automatically scrap personal identifiers from whatever variety streaming data. Our society is becoming increasingly dominated by electronics and wireless communications, both enablers but prone to devastating cyber attacks. Privacy, security, and safety are forefront challenges of the data-driven society, and ECE faculty's research has made significant progress on all fronts from the cyber to the cyberphysical world. *Contact: Virgil Gligor.*

Analytics



Data comes in new formats that defy traditional analytics and processing methods. Beyond the simple regular structure of traditional time- and space-dependent physical signals be they time series, speech, audio, images or video, data may arise from multiple networks of multimodal, arbitrarily placed sensors, or from other contexts that range from the social to the biomedical, from the molecular to the chemical, from the healthcare to the enterprise, from the arts to the web. ECE has expertise in developing principled solutions to the mining of these, possibly distributed, complex, and unstructured large datasets, contributing to defining and advancing the methodologies that go from data to information to knowledge. Such knowledge gives opportunity for better apportioning of resources, administering infrastructures, or developing educated policies that are adequate for target applications. *Contact: José Moura.*