Geoscience Computing Trends: Interconnected, Autonomous, and Immersive Computing Platforms

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Big Ideas in Computer Science Impacting the Geosciences

One impactful idea has been the use of the Internet to organize large scale scientific collaborations, and in particular, citizen science. Citizen science predates the Internet, with the Audubon Christmas Bird Count as an example dating back over 100 years. Additionally, the Internet has long supported scientific collaborations and hosted remote access to computers and sensor platforms of interest to geoscientists. However, the broad reach of the Internet makes it a suitable platform for democratizing scientific research and enlisting the support and participation of citizens. SETI@Home was an early example of users volunteering computer cycles for radio astronomy signal processing. Later efforts enlisted citizens as more active contributors, such as Stardust@Home, a project to identify interstellar dust particles captured by a NASA spacecraft. The Internet can be a great conduit for broad collection and dissemination of scientific and environmental data.

A second idea is the emergence of robotic drones which can navigate autonomously and collect environmental data. Aerial and ocean going drones are being used to capture a variety of data, such as temperature, salinity, and pollutants. An example of related work at ICT is the Terrain 2025 project, which is developing a robust pipeline to process videos, taken by aerial drones, in order to extract 3D terrain and to classify roads, buildings, and vegetation.

A third idea is that virtual reality (VR) and interactive user interfaces will alter how humans interact with complex data and improve tools for communicating and collaborating. With the emergence of low cost virtual reality technologies such as the Oculus Rift, data visualization can be facilitated by high bandwidth 3D interfaces that leverage more of a user's spatial cognition and motor abilities. Users will be better able to explore and understand data that is presented in 3D, with interactive capabilities for navigating, collaborating, and manipulating that data.

Research Trends Relevant to Workshop Goals

As a researcher in the field of human-computer interaction, I seek to create user interfaces that provide the power, flexibility, and expressiveness needed for users to visualize and analyze their data. Funded by DARPA and Microsoft Research, ICT has explored powerful multi-touch interaction techniques on large touchscreen surfaces for searching and understanding interconnected data. We have also explored multi-touch techniques for visual programming languages for data processing.

It is also important to develop visualization tools that leverage human capabilities in spatial cognition, pattern recognition, and creative insights. ICT pioneered the development of low-cost virtual reality systems, including smartphone and tablet based VR displays. Such design approaches were later adopted in products such as the Oculus Rift, Samsung Gear VR, Valve/HTC Vive, and Google Cardboard. I have employed ICT designed VR displays for visualizing "Big Data" within the DARPA XDATA program. Such VR platforms could also help remotely located human collaborators work together on complex data sets.

Another vital research area is studying how users can partner and share workloads with intelligent systems that can also recognize patterns and provide valuable insights. Many researchers, including those at ICT, have been exploring how computers can be represented by socially aware user interfaces, personified by "virtual humans." Such characters can act as guides or tutors to help explain phenomena within the data and help users choose appropriate analytical tools.