2023 HAWAII UNIVERSITY INTERNATIONAL CONFERENCES
SCIENCE, TECHNOLOGY & ENGINEERING, ARTS, MATHEMATICS & EDUCATION JUNE 7 - 9, 2023
PRINCE WAIKIKI RESORT, HONOLULU, HAWAII

EDUCATION ON GIGAPIXEL ABUNDANT-CHANNEL (GIANT) IMAGE ANALYSIS: APPLICATIONS AND CHALLENGES

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Education on Gigapixel Abundant-channel (**GIANT**) Image Analysis: Applications and Challenges

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1 Definition

This article introduces the concept of GIANT (GIgapixel AboundaNT-channel) images, which are images with a minimum of one billion pixels and exceeding five channels. These images are obtained through advanced imaging technologies and are proficient in recording an extensive array of data, making them widely applicable in fundamental scientific research. However, the education on acquiring, applying, and analyzing GIANT images in college education faces presents several significant challenges, including acquiring and processing the images, scalable learning, and computing cyberinfrastructure. Understanding these challenges is crucial for developing educational programs and tools for processing and analyzing GIANT images in various scientific disciplines.

2 Applications in STEM Fields

Image resolution and the number of channels are two critical attributes that dictate the size and complexity of an image. a category of images known as **GIANT** (GIgapixel AboundaNT-channel) images. Each image within this definition possesses **a minimum of one billion pixels** (Giga-pixels) and **exceeds five channels** (surpassing conventional camera/microscope images).

GIANT images are primarily obtained using advanced imaging technologies, such as high-dimensional virtual microscopy [1, 2, 3], which enable the capture of a comprehensive range of information. Examples of such images include, but are not limited to, multi-channel whole slide images (WSI) [4, 5], multiplex immunofluorescence (MxIF) images [6, 7], high-resolution fluorescence in situ hybridization (FISH) images [8, 9], and sophisticated spatial transcriptomics (ST) images [10, 11] (**Fig. 1**). These GIANT images are proficient in recording an extensive array of data, encompassing multiple color channels, depth information, and other data types like temperature, metabolic activity, or gene expression profiles.

GIANT images are widely applicable in fundamental scientific research, particularly in disciplines like biology, medicine, materials science, and remote sensing. Microscopic images facilitate the examination of intricate biological systems and the composition of materials, while remote sensing generates high-resolution satellite imagery. For example, the GIANT images permit the visualization of thousands of genes at the subcellular level with single-molecule sensitivity and gigapixel resolution, offering unparalleled spatial information.

3 Challenges in College Education

Despite their numerous advantages, education on acquiring, applying, and analyzing GIANT images presents several significant challenges, including but not limited to:

Accessibility: Acquiring GIANT images entails ensuring that the various channels and layers of the image are precisely aligned with one another, which can be a computationally demanding task. Therefore, only flagship R1 research universities have the access to such advanced imaging equipments and facilities. The collaboration between such institutes with nearby colleges and K-12 schools is essential.

Course Coverage: The immense size and high resolution of GIANT images lead to extended processing durations. For example, implementing deep learning-based image computation on a single gigapixel image may take several hours or even days to complete. It is a mathematical and algorithmic intensive field which requires the coverage of advanced computer theory, image processing, and

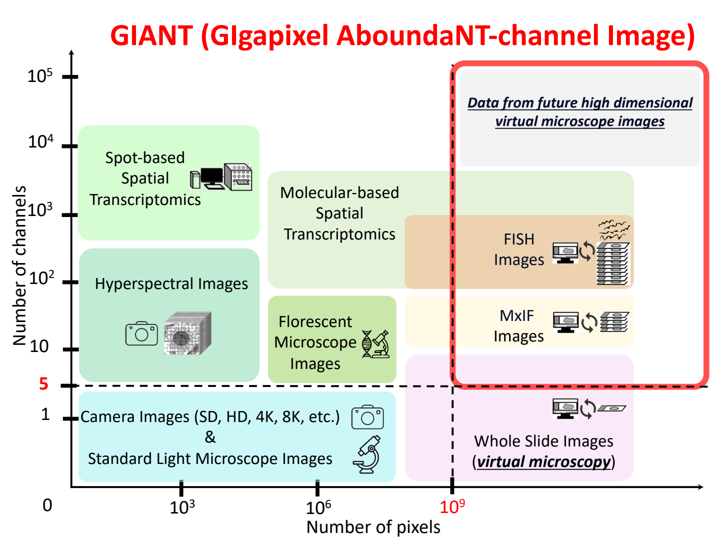

Figure 1: Definition of the GIANT image.

database courses in STEM majors, such as computer science, electrical and computer engineering, and biomedical engineering.

Computing Cyberinfrastructure: The processing of GIANT images generally requires formidable computing resources, including advanced GPUs, high-performance computing clusters, or cloud computing platforms. Procuring and operating these resources can be expensive and may call for specialized IT expertise to ensure efficient setup and usage.

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