Facilities and Other Resources

The University of Iowa

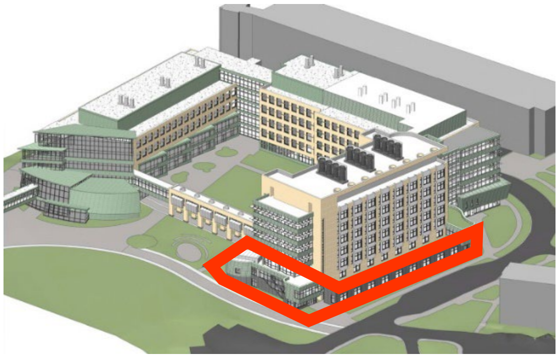
The University of Iowa Roy J. and Lucille A. Carver College of Medicine (CCOM) (~1000 faculty) is currently ranked 11th among public medical schools by *US News and World Reports*, and 10th among public medical schools for NIH dollars/faculty member. It is home to four Howard Hughes Medical Institute investigators and 17 members of the Institute of Medicine.

Iowa Institute for Biomedical Imaging

Co-Director: M. Sonka

The Iowa Institute for Biomedical Imaging (IIBI) was formed in 2007 as an acknowledgment of a long history of interdisciplinary collaboration at the University of Iowa. The formation of the inter-disciplinary institute reflects a strong institutional support to biomedical imaging and image analysis as well as to translational medical research. The IIBI brings together more than 60 faculty members (out of which over 45 hold faculty positions in the Carver College of Medicine, 15 hold faculty positions in the College of Engineering with a primary expertise in biomedical image analysis) and over 60 graduate students and postdoctoral fellows. The mission of IIBI is *to foster efficient and cooperative inter-disciplinary and cross-college research and discovery in biomedical imaging, and to improve training and education within the broader community at the University of Iowa*. The Institute is finding its new home in two stories of a 100,000 sq.ft. University of Iowa *Pappajohn Biomedical Discovery Building* that was completed in 2014 – the floor plan and photographs are provided below. The IIBI space in this new building (30,897 sq.ft.) are devoted to human, large, and small animal imaging, image analysis, computational support, visualization, and biostatistical support. The IIBI space in the new building is the new integrated home for a large number of image analysis projects that are currently ongoing at the University of Iowa and will therefore further enhance close interaction within the University of Iowa biomedical imaging community.

The opening of the new facility, which is 100% devoted to research while located in an immediate proximity to the University of Iowa Hospitals and Clinics, represents a new chapter in IIBI's existence and adds 30,897 sq.ft. of new imaging research space to IIBI, for a total of over 37,000 sq.ft. dedicated to small and large animal, and human imaging. The new facility brings together small animal housing (managed by the Office of Animal Resources); 1 floor of small animal imaging (5,544 sq.ft.) with 9 barrier/non-barrier scanner rooms, 6 imaging rooms, 1 data analysis room, 5 animal housing rooms, as well as research staff office space; and another floor (20,081 sq.ft.) devoted to human and large animal imaging and translational medicine research with 4 large scanner bays, cardiovascular imaging suite, LINAC radiation delivery bay (animal research only), virtual/augmented reality visualization suite, subject preparation rooms, meeting rooms and student/postdoc office cubicles. Research faculty/staff offices (2,627 sq.ft.) are adjacent. Animal housing is located in the basement of the new building, with 7,225 sq.ft. of animal vivarium space completed at the time of opening offering barrier and non-barrier housing, animal preparation rooms, and animal surgical suites (2,645 sq.ft.), with additional 22,689 sq.ft. of future vivarium expansion space built and unfinished (framed) at this time.

In the imaging space, a complete separation of human and animal access has been an important part of the programmatic design, animal and human research can be conducted simultaneously at different imaging bays with complete separation of access routes. Similarly, small animal scanners can be used for barrier and non-barrier animals with two separate and secured access doors from two separate hallways. Additionally, three of the four ground-level imaging scanner bays have been designed in a modular way with a removable wall to allow relatively easy way to install and/or replace whole-body imaging scanners as well as to allow installation of scanners from different manufacturers. The fourth large scanner bay has been specifically designed for a 7T MR scanner which is now fully operational. Existing IIBI space in two adjacent buildings house a dedicated research 3T MR scanning facility (1,500 sq.ft.) and a dedicated dual-source CT scanning facility (1,800 sq.ft.). Additional 3,000 sq.ft. of computer-lab student cubicle space is available in a short walking distance. The IIBI facility is connected with a state-of-the-art Data Processing facility that houses file servers, compute-servers, data analysis clusters, and is connected to the IIBI space with ultrafast network connection (10 Gb/sec network speed).

The remaining 6 floors of the Pappajohn Biomedical Discovery Building house translational research wet labs occupied by research programs that require animal and translational imaging support. Among other research groups yet to be determined, the following research groups found their new home in the wet-lab space of the Pappajohn Biomedical Discovery Building: Diabetes Research Center, Pulmonary Airway Biology Center, Neuroscience Institute.

The following figures show the design of the two IIBI floors, color labeling identifies different programmatic functions.

The small animal imaging suite is equipped with the following:

- Siemens INVEON PET/CT/SPECT small animal scanner
- 7.0T GE 901 Discovery MRI Small Animal Scanner
- FUJIFILM VisualSonics Vevo 2100 small animal ultrasound scanner
- Perkin Elmer Lumina S5 2D optical imaging system
- Carestream MSFX-Pro Multi-spectral X-Ray imaging system
- Xstrahl Small Animal Radiation Research Platform (SARRP)

- Zeiss Xradia 520 Versa 3D X-ray Microscope
- PerkinElmer Wizard^2 2480 Detector Automatic Gamma Counter
- QScint T00-iQID Alpha camera imaging system
- 4 Dell Workstations for image processing and data analysis

The large animal/human imaging floor is equipped with:

- GE SIGNA 7T MRI whole body human/animal research scanner
- GE Premier 3T MRI whole body human/animal research scanner
- GE Discovery PET/CT whole body human/animal research scanner
- 3D/4D virtual/augmented reality visualization laboratory
- Human/animal dual-source CT – Siemens Somatom Force research suite
- One additional large scanner bay (capable of housing PET, CT or MR scanners, equipped with MR shielding for scanners up to 3T) is ready to accept new whole-body imaging devices to support large animal/human/translational imaging research

Computational and Informatics Resources

The University of Iowa has two centrally managed enterprise data centers containing dedicated space, power and cooling for University of Iowa Research and a third server room entirely dedicated to research computing. Altogether, these data center spaces are ultimately designed to deliver 1.2 megawatts of power and associated cooling with approximately 4,800 square feet of securely managed and maintained raised floor capacity for research computing. The newest of these data centers, the Information Technology Facility (ITF), is located on the University of Iowa Research Park campus and utilizes multiple-10 Gigabit Ethernet circuits along diverse physical paths to connect to both the main campus network cores and the local-to-campus alternative data center. Distribution networks within data centers are a combination of multiple-10 Gigabit Ethernet circuits to data center-class network gear, providing 1 Gigabit and 10 Gigabit Ethernet service, and via direct fiber (e.g., for fiber-channel storage). Research computing within each campus data center is segregated from university line-of-business networks to provide isolation and performance-tuning optimizations.

ITS Research Services manage High Performance Computing (HPC) resources available to UI researchers. The University of Iowa Argon High-Performance Computing cluster consists of 366 compute nodes running CentOS-7.4 Linux. Each node has 96--512GB of memory and 40-56 cores. Out of these, >150 nodes have >310 GPU accelerator cards (Nvidia P100, Nvidia K80, Nvidia P40, 1080Ti, and Titan V) supporting deep learning and artificial-intelligence computing. The Rpeak (theoretical Flops) is 385.0 TFlops, not including the accelerators, with 89.7 TB of memory. In addition, there are 2 login nodes of the Broadwell system architecture, with 256GB of memory each. The Argon cluster is the result of combined central funds and researchers' pooling of funds in a centrally managed and maintained HPC environment.

In addition to the cluster resources, we have compute servers with 256GB to 1.5TB of main RAM, running either Ubuntu 20.04 or OpenSUSE 15 Linux, several of which have performance-accelerating GPU cards: one with quadruple NVIDIA Tesla V100, resulting in128GB GPU RAM connected via NVlink; two with dual NVIDIA Quadro RTX8000 with 96GB GPU RAM. For fast access to the data, we have 418TB net available storage capacity on dedicated IIBI file servers, with up to 10Gb/s network speed. The computational environment is being kept at the leading edge of hardware and software resource availability.

Software available on desktop systems includes a variety of packages. All systems have standard software like Web Browsers, E-mail applications, Microsoft Office 2010 Professional (Word, Excel, PowerPoint and Access) or OpenOffice, and a number of utility and multimedia applications loaded on them. Fast link Internet connection exists between the hospital and the image analysis laboratory. The medical image analysis laboratories are especially equipped with the environment for software development. All computers have common software for programming in a variety of languages including C, C++, Java, Python, and many other programming languages, statistical packages, 3-D visualization packages, debugging packages, etc. The software also includes in-house developed library of 3D and 4D image analysis software tools, including capability to read and analyze medical file sets in compliance with the DICOM standard. Members routinely develop original programs for biomedical image analysis and as such, the disk contents of all research computers are routinely backed up for information security. Other applications are purchased on as needed basis.

Deep Learning Development Lab – to support seamless transition between the environment for development of deep-learning methods and applications and the high-performance computing cluster for production-level computing, a development lab has been created with 12 HP Z4 series Linux-Ubuntu computers specifically supporting deep learning and GPU computing. Each of these machines has 32 GB of RAM, 1 TB of NVME storage, and one (6) or two (2) GTX 1080Ti or 2080 Ti video/GPU card(s). Each machine offers Ubuntu 20.04 LTS operating system and software supporting deep learning and GPU application development: Singularity, Anaconda3 (conda 4.9.2), Spyder 4.8.5, Jupyter 4.6.3, NVidia CUDA v10.2, CuDNN libraries v7.6.5, NCCL v2.3.4, and Tensorflow-gpu v2.2.0 with python3.8.5.

Biostatistical Resources

The University of Iowa has dedicated office space and computing facilities for statistical personnel. Biostatistical staff members have access to common statistical programs to perform necessary job duties, including R, SAS, SPSS, and Matlab. Additional statistical software programs necessary to perform work are evaluated and purchased as needed.

Statistical personnel at the University of Iowa have access to resources to participate in collaborative research grants, including meeting rooms with computing and teleconference equipment to converse, provide presentations, and interact with internal and off-site researchers.

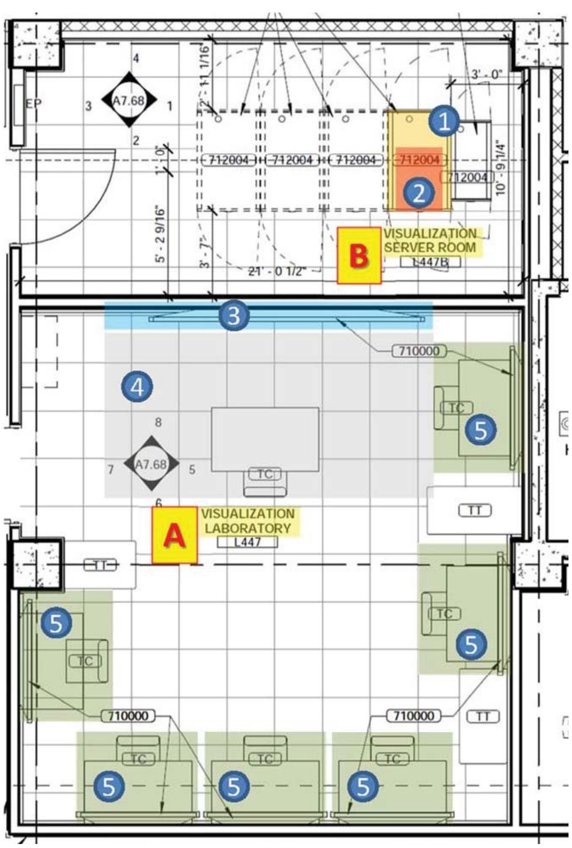
All appropriate and necessary ancillary equipment and personnel expertise are available to foster the day-to-day responsibilities and activities associated with this grant.

Visualization and Analysis Laboratory Environment

The visualization facility in the new Pappajohn Biomedical Discovery Building is a part of the Iowa Institute for Biomedical Imaging and includes state-of-the-art devices and computational resources that greatly benefit interdisciplinary biomedical imaging research at the University of Iowa. The lab consists of two adjacent rooms: [A] the visualization laboratory itself, and [B] visualization server room (see Figure).

The visualization laboratory [A] includes the following major components:

- A large collaborative interactive 3D (stereoscopic) visualization environment (consisting of 3D display wall and motion tracking system, see figure), which enables collaborative visual data exploration, algorithm interaction applications, interactive modeling of objects, virtual reality visualization, and is specifically configured to support biomedical imaging and analysis projects. Its secondary functionality includes educational and 3D prototyping/visualization capabilities.
- Six high-performance visualization workstations (some are shown in the figure) enable up to six researchers/students/ small collaborative groups to develop visualization and data analysis applications/software solutions, application of developed visualization software by a single user, and/or training of students in parallel. Functionally, each workstation is identical and is configured as a scaled-down version of the large collaborative interactive 3D (stereoscopic) visualization environment described in the previous bullet, therefore facilitating seamless transition between the individual workstations and the large-panel visualization environment. Additional workplaces will be added as the need grows.



The visualization lab was planned such that once a visualization application is designed and functionally tested on one of the high-performance visualization workstations, users and user groups can run the same programs on the large collaborative interactive 3D (stereoscopic) visualization system. Simultaneously, this design allows multi-developer efforts to be undertaken in parallel and thus supports multi-developer collaborations on a specific project. This concept enables the efficient utilization of the visualization lab [A] by up to 7 development and/or analysis/exploration projects or teams at any single time.

High-performance workstations are built as desktop stations ready for bi-directionally translating methods and development-results from/to the central collaborative station described above to/from cost- and space-efficient workstations. Identically configured workstations can later be deployed at target application locations (e.g., at translational research or clinical medicine facilities) as a relatively inexpensive yet highly efficient image analysis/visualization workplaces ready for practical adoption by end-users.

The visualization server room [B] houses high-performance graphics computing equipment required for driving the large 3D display wall as well as other computing/graphics servers and additional on-site disk space, as required by specific research projects. The water-cooled rack (object 1 in the figure) provides the necessary cooling of high-performance hardware and can handle heat loads of up to 25 kW.

Personnel

Administrative personnel with various functional responsibilities (e.g., finance, project management) are available to assist with the organization of the administrative team, the associated coordination of activities, the financial monitoring and the process of moving the projects forward.

Environment

Contributing to a rich scientific environment are other members of the Iowa Institute for Biomedical Imaging, the largest College-of-Engineering based medical imaging research group in the nation, with 11 faculty working in this research area.

Informatics – Data Storage

All research data for all ongoing image analysis projects are stored in a research image database system (research PACS – XNAT). This research imaging database now accepts all kinds of medical image formats, including fundus photography, fluorescein angiography, OCT, as well as visual function test data and patient demographic data. Data are available to the researchers based on their affiliation to the project as stated on IRB documents. All data are de-identified as part of the data-upload process – therefore, no identifying information is included in the research database.