Auto-driving Vehicle-based Affordable Tomography-Analytics Robots (AVATAR)

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Civilization Spanned by Mobility & Connectivity – Rail/bus stations made milestones in the transportation history but quickly overwhelmed by privately-owned cars. Now, Uber taxi become popular, and auto-driving cars are on the horizon. Similarly, supermarkets/malls are where we shop but the trend is moving towards internet-shopping and door-to-door delivery. Not long ago, we used to go to cinemas and theaters for entertainment. Then, we built home theaters. Today, we use smart phones to watch TVs most of the time. Yet, many believe that the blockchain technology will revolutionize the society; say, eliminating banks. In summary, after “Internet of information”, “Internet of things” are under active development, and “Internet of service” seems the next wave. The individualized and optimized use of information, products, services demands decentralization, interconnection, and machine intelligence, promoting democracy and improving quality of life.

Importance of Medical Imaging – Human vision is a primary source of information. Among all NIH institutes, the only institute not directly related to human organs and diseases is NIBIB, an imaging/BME institute. Medical imaging is a multi-billion dollar business, brings tremendous healthcare benefits, undergoes dramatic transformation, and promises a major societal impact.

Future of Medical Imaging – We envision a paradigm shift in medical imaging, from hospital/clinic/center-oriented to mobile, intelligent, and integrated services promptly delivered wherever and whenever needed. The Auto-driving Vehicle-based Affordable Tomography-Analytics Robots (AVATAR) are most desirable on natural disaster spots, after terrorists’ attacks, and near battle fields. Also, AVATAR are advantageous in routine healthcare imaging such as cancer screening because of potentially much-reduced cost, full automation, and greatly-improved convenience, especially for rural areas and under-developed countries.

Convergence of Maturing Engineering High-techs – Given unprecedented progresses in the engineering field over the past decade or so, AVATAR is timely to integrate cutting-edge medical imaging, machine learning, robot, high-performance computing, internet, and auto-driving technologies, and change the landscape of the imaging world. In the last year, we argued that “Machine learning will transform radiology significantly within the next 5 years” (https://aapm.onlinelibrary.wiley.com doi/pdf/10.1002/mp.12204). Coincidentally, with several good reasons many people believe that you will have autonomous cars within 5 years (https://www.quora.com/When-will-self-driving-cars-be-available-to-consumers). Also, Boston Dynamics is famous for the development of quadruped robots with amazing performance in battle fields (https://www.bostondynamics.com), supported by DARPA and DI-Guy. These and other techniques are rapidly evolving, and can be now combined to make AVATAR prototypes.

ERC Center for AVATAR – The overall goal of the proposed ERC center is to develop AVATAR prototypes as testbeds for cancer screening and global disaster relief (in collaboration with Massachusetts General Hospital), as well as military trauma care near battle fields. The initial imaging modality for AVATAR will be x-ray computed tomography (CT), and other imaging modalities such as ultrasound and optical imaging, MRI and nuclear imaging will be added as the project goes on. AVATAR will implement critical imaging capabilities previously unavailable and/or achieve a fraction of the total cost of today’s corresponding imaging procedures. Auto-driving cars, autonomous drones and walking robots can be the vehicles of interest. AVATAR will be featured by clean power, small footprint, high flexibility, smart operation, and internet-connectivity.

Preliminary Studies Related to AVATAR – An AVATAR CT scanner will be developed in reference to the prototype we designed several years ago, http://live.iop-pp01.agh.sleek.net/2015/01/28/how-to-create-a-low-cost-ct-scanner, which is already an order of magnitude cheaper than the current commercial products. More than two years ago, our group started working on machine learning for medical imaging especially tomographic reconstruction and end-to-end analysis (https://ieeexplore.ieee.org/document/7733110/?reload=true), recently funded by GE Global Research Center (GRC). Our existing design and methods will be improved in collaboration with GRC and other partners, based on rapidly-evolving low-power light-weight x-ray tubes and integrated generators, high-resolution and photon-counting detectors, low-dimensional manifold and data-driven machine learning, smart materials, computer vision, language translation, high-performance computing, and robotic technologies, for a good portion of which RPI has world-class expertise on campus.