Contract No:

This document was prepared in conjunction with work accomplished under Contract No. DE-AC09-08SR22470 with the U.S. Department of Energy (DOE) Office of Environmental Management (EM).

Disclaimer:

Title: Limited-view 3D Imaging Technology or "LV 3D Imaging" Technology Assessment

Limited View 3D or "LV 3D" imaging is important because it addresses a technology gap that has life, time, radiation dose and monetary-saving impacts. It provides something that currently does not exist and its potential products open a variety of technology domains in which SRNL could become competitive in. It can become a low cost, safer and alternative approach to conducting what is commonly referred to as computer tomographic imaging. This project develops a bucket list of technologies that will be needed to develop a portable system for conducting LV 3D imaging.

Awards and Recognition

A two-year $200 K grant from the Grayson-Jockey Club Research Foundation was awarded to Colorado State University (PI: Dr. C. Kawcak), the University of Chicago (Co-PI: Dr. X.C. Pan) and Savannah River National Laboratory (Co-PI: Dr. M.C. Duff) for LV 3D imaging studies with equine lower limbs. This seedling LDRD was used as leverage support for the FY18 Grayson proposal, which was awarded in April 2018.

Intellectual Property Review

This report has been reviewed by SRNL Legal Counsel for intellectual property considerations and is approved to be publically published in its current form.

SRNL Legal Signature

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Signature **Date**

Limited-view 3D Imaging Technology or "LV 3D Imaging" Technology Assessment

Project Team:

Drs. M.C. Duff (Primary) and D.D. Dick

Subcontractor:
Drs. X.C. Pan and E. Sidky,
University of Chicago

Thrust Area: Process Imaging
Emerging Competency in the NS Area

Project Start Date: Oct. 1, 2017
Project End Date: Sept. 30, 2018

The goal of this project is to generate a list of technology needs that would be required for the acquisition of X-ray images that will be used in Limited View (LV) three dimensional (3D) or "LV 3D" imaging.

FY2018 Objectives

- Generated a list of components that would be needed for the prototype imaging system.
- Worked on the setup of a subcontract with the University of Chicago.
- Pursued funding from external agencies including the Grayson-Jockey Club Research Foundation.

Introduction

The concept for this technology for LV 3D imaging was developed in 2011 by a DOE-funded collaboration with the University of Chicago (UC). Fast 3D imaging is an impressive, non-destructive diagnostic technique that can be used with unknown objects. Traditional 3-D computer tomography (CT) requires heavy, cumbersome machinery and >thousands of DR images to create a usable product. Traditional CT is not highly field-deployable, particularly for items that reside in extreme environments, confined spaces, high radiation areas, limited/denied access areas, are needed and when robotic access is required.

LV 3D imaging work was developed by UC and SRNL. It is important because it addresses a technology gap that has life-, time-, radiation dose- and monetary-saving impacts. It provides something that does not exist and its products would open a variety of technology domains in which SRNL would become competitive. Our UC collaborators have developed and extensively tested their computational methods. The UC has demonstrated their results through the publication in high level research journals, patents and in their collaboration with SRNL. The UC's Total Variation or "TV" -minimization algorithm has been used to perform 3D image rendering and tomosynthesis with sparse, highly incomplete data sets (used in **Fig. 1**).

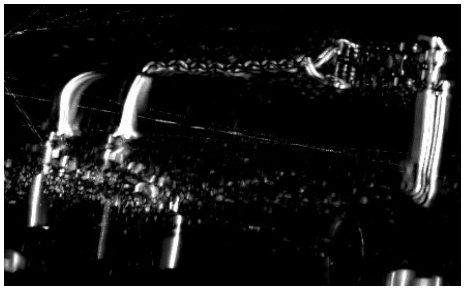

Figure 1. A still image from a video of an object that was acquired using 20 images and the UC TV algorithm. Work performed by SRNL and UC.

Approach

Traditional CT is not highly field-deployable because the imaging system is heavy and cumbersome. This type of CT is cumbersome in part because it contains x-ray shielding that must be available in all dimensions (within the outermost part of the machine) that the X-rays will potentially penetrate during imaging. Traditional CT also must have a predefined internal path by which the images are acquired around the object of interest. This "path" provides a strict geometry that is maintained during the acquisition of nearly 1000 equally spaced digital X-ray based images around the object of interest. Use of this confined path geometry is a requirement for traditional CT algorithm. In contrast, the UC algorithm

does not require the same confined imaging setup as traditional CT. The UC algorithm permits the use of only a handful of digital X-ray images. This seedling proposal surveys the technology that will be needed so that X-ray images can be acquired and rendered in 3D using UC's algorithm, compressive sensing and sparse data. Our seedling project creates a list of items that are part of a conceptual design for a prototype imaging system. A list of components (some software and but mostly hardware) that will assist with the georeferencing during the acquisition of images for <30 cm^3 items of X-ray interest was generated. This is the product that will be presented to customers.

Results/Discussion

The ability to achieve adequate georeferencing is paramount to the success of this technology once a customer has identified that will fund for the work.

FY2018 Accomplishments

This small project addresses a need for generating a bucket list of possible technologies that would assist in the development of a prototype.

- We determined that at least 7 types of portable and lightweight technologies (including shielding) will be needed to test the acquisition of the georeferenced images that can be rendered in 3D.
- Local WIFI, gyroscopes, and local Global Positioning Service (GPS) are just some examples of technologies that would potentially be needed.
- Several types of widely used open source "free-ware" software packages could be utilized to manipulate the images once they are rendered.

Future Directions

Our primary objective is to obtain funding for the development of this technology.

FY 2018 Publications/Presentations

1. A presentation of this work was given to a potential customer in fiscal year 2018. A proposed project is currently under consideration for funding in mid-2019.

References

None.

Acronyms

CT: Computer Tomography
DR: Digital Radiography
GPS: Global Positioning Service
LV 3D: Limited-View Three Dimensional
TV: Total Variation
UC: University of Chicago.

Intellectual Property

None.

Total Number of Post-Doctoral Researchers

One.