NIMBioS
National Institute for Mathematical and Biological Synthesis

Automatic 3D Modeling of Human Morphology and Body Composition

http://www.nimbios.org/workinggroups/WG_3d

Project Summary

Laser imaging and other related new imaging technologies provide a novel opportunity for automatically rendering 3D images of the human body. These major advances are eliminating reliance on burdensome and often inaccurate anthropometric clinical and research measurements that are widely used in evaluating subjects with a range of medical conditions.

The working hypothesis of this meeting is that these new 3D imaging system will greatly expand clinical and research phenotyping and disease-predicting capabilities. The developed models will also have applicability in other areas of human biology and physiology research.

The purpose of this working group is to bring together a uniquely diverse and highly qualified team of investigators from two areas, body composition and mathematical modeling research to:

1) Review development approaches for state-of the art software for 3D image reconstruction

2) Evaluate approaches for automated anatomic land-marking and conversion of collected 3D image data to body shape and composition estimates (fat, skeletal muscle, and bone),

3) Develop cardiovascular and diabetes risk indices that align to available geometric measurements of body shape acquired from the 3D images,

4) Explore other potential applications of segmented 3D images as may apply in non-medical settings, and

5) Design and clinically deploy user-friendly software tools to automatically deliver body composition and health risk predictions.

SPECIFIC AIMS

The overarching aim of this project is quantify body composition and health risks from automatically generated 3D images of the human body. Despite advancement in imaging technology, accurate mathematical models that predict body shape and composition along with health risks from captured images does not yet exist.

The NIMBioS meeting in March will address this gap with the following aims:

<u>Aim 1.</u> Translate body geometric models from the 3D images to predict body shape and composition.

<u>Aim 2.</u> Develop new metrics of health risk that were not previously possible due to sole reliance on clinical measures like BMI.

<u>Aim 3.</u> Deliver model predictions in a user-friendly software platform.

We envision that these initial discussions will eventually lead to automatic assessment platforms that image subjects, predict body composition and shape, and send health risk information to health care professionals in real-time.

Pre-session activities

A list of reading materials on body composition assessment, 3D imaging technology, and the current state of mathematical modeling in the field will be provided to participants. Participants will assign themselves to summarize two publications for the group. Two months before the first meeting, a bi-weekly seminar will take place that covers material using on-line technology.

On-site activities

The agenda will include didactic lectures set up in a module format. The first lectures in the morning session and afternoon session will provide background and statements behind the Specific Aims. We will break out into smaller groups at the end of the afternoon session and draft project summaries/specific aims and key words for searches to develop our systematic review. Computer imaging and modeling teams will break out to discuss forward directions and challenges. Specific discussion will involve the development of preliminary data for proof in concept. The second day will consist of presentations based on Day 1 sessions and a series of next steps.

Metric of success

We envision several publications arising from our working group. The first publication will be a review paper on existing mathematical models in the field of body geometry, body composition, and health risk. This review article will set the stage for advancement for more sophisticated and accurate models using 3D rendered body images. We also plan to develop software that provides accessible delivery of model predictions for application.

Participants

Participant	Organization	Topic of Expertise
Steve Heymsfield, M.D.	Pennington Biomedical Research Center, LA	Body Composition
COL Michael Yankovich	US Military Academy, NY	Dynamical Systems/Statistics/Operations Research/Networks
Diana Thomas, Ph.D.	US Military Academy, NY	Dynamical Systems, Machine Learning, Geometry, Combinatorics
Nakeya Williams, Ph.D.	US Military Academy, NY	Cardiovascular Modeling
Dympna Gallagher, Ed.D.	Columbia University, NY	Body Composition
John Shepard, Ph.D.	UC San Francisco, CA	Body Composition/Data Processing
Courtney Peterson, Ph.D.	Un. Alabama, Birmingham, AL	Body Composition/Physics/Scaling Laws
Satish Viswanath, Ph.D.	Case Western, Cleveland, OH	Computer Science, Image Processing
Isaac Tian, M.S.	University of Washington, WA	Computer Science, Image Processing
Gary Zientara, Ph.D.	MEDCOM, USARIEM, Natick, MA	Image Processing
CPT Patrick Kuiper	US Military Academy, NY	Machine Learning, Data Analytics
COL Doug McInvale	US Military Academy, NY	Operations Research

Program

Time	Speaker	Topic
Day 1 - Mon 3/13/2017		
8:30-9:00 am	Diana Thomas, USMA	Introductions/Greeting
9:00-10:00 am	Steven Heymsfield, PBRC John Shephard, UCSF	Description of 3D Laser Technology, Data, and open modeling/imaging questions
10:15 – 11:00 am	Dympna Gallagher, Columbia, NY	Current state of anthropometric measurements, DXA and MRI quantifications
11:00 – 12:00 pm	Diana Thomas, USMA Courtney Peterson, UAB	Body Shape and Geometry to Predict Body Fat, Body Fat Distribution, and Health Risk
Group Photo 12:00 pm		
Lunch 12:00-1:00 pm		
1:00-2:00 pm	Michael Yankovich, USMA	Modeling Risk from Body Measures
2:00-3:00 pm	Satish Vishwanath, Case Western	Computer assisted detection body composition in MRI
3:15-4:30 pm	Breakout Roundtable Groups	Development of Specific Aims, Key words for Review Article, and Project Narratives
4:30-5:00 pm	Steven Heymsfield, PBRC Diana Thomas, USMA	Summarize Breakout Group Discussion
5:00 pm	NIMBioS Reception	
Day 2 - Mon 3/14/2017		
9:00-10:00	Computer Imaging Participants	Potential Problems, Requirements, Advances
10:00-11:00	Diana Thomas, USMA Nakeya Williams, USMA	Synthesis of Potential Modeling Paths

	Courtney Peterson, USMA	
11:00-12:00	Steven Heymsfield, PBRC	Next Steps/Closing

Guiding questions

- What are the requirements/technology needed to obtain optimum data for creating avatar? (See below)
- Do 2D images taken from cell phone cameras offer important opportunities?
- Can the avatar be deconstructed into image segments that yield new body shape and body composition measures that predict health, performance, and physiological outcomes?
    - How will these segments or anatomic features be determined?
    - Can the process be automated or will markers need to be placed on the subject?
    - What segments are the most critical to obtain?
    - Are there methods we may employ to obtain challenging measures such as sagittal diameter?
    - Is there is a role for "machine learning" in identifying the body shape indices.
    - Are there advanced statistical methods--such as principal components analysis or factor analysis--for determining the minimal number of body shape indices needed to quantify cardiometabolic disease risk.

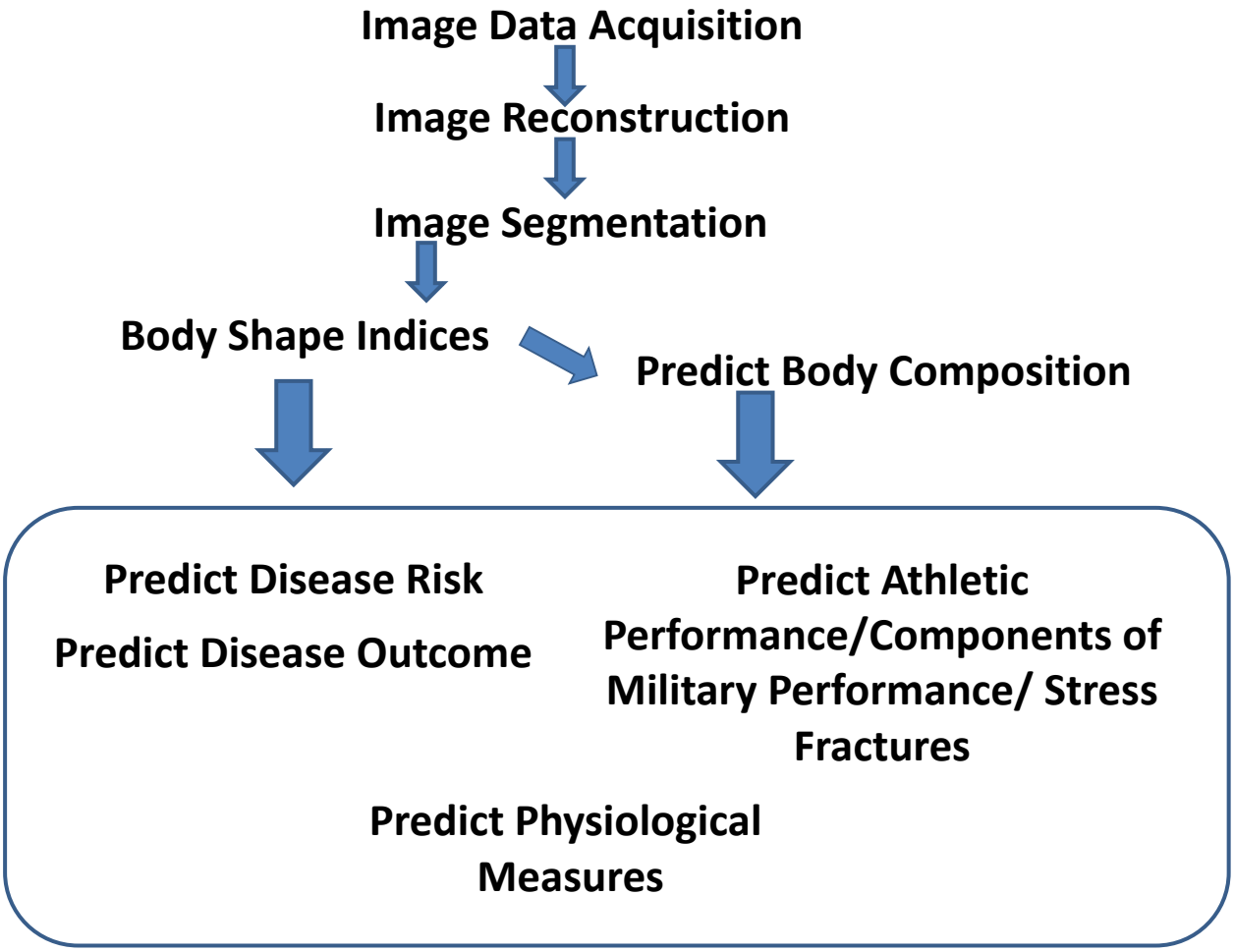
Image Data Acquisition
Image Reconstruction
Image Segmentation
Body Shape Indices
Predict Body Composition
Predict Disease Risk
Predict Disease Outcome
Predict Athletic Performance/Components of Military Performance/ Stress Fractures
Predict Physiological Measures