Nurse-Managed Technology to Enhance Cancer Care Outcomes for Survivors with Breast Cancer or Head/Neck Cancer

**Summary:** Technology developed by nurses and their multidisciplinary collaborators for enhanced care outcomes for persons diagnosed with breast or head/neck cancer will be presented. Technology for (1) mobile-device assessment of limb swelling, (2) machine learning and touchscreen reporting, (3) integration of assessment data into the medical record, and (4) head/neck lymphedema assessment will be demonstrated.

**Moderator:** Melissa A. Stec, DNP, APRN, CNM, FACNM  
College of Nursing, University of Cincinnati, Cincinnati, OH

**Symposium Organizer:** Jane Armer, PhD, RN, CLT, FAAN  
Sinclair School of Nursing and Ellis Fischel Cancer Center  
University of Missouri, Columbia, MO, USA
Nurse-Managed Technology to Enhance Cancer Care Outcomes for Survivors with Breast Cancer or Head/Neck Cancer

2:30-2:50 Mobile Platform for Assessment, Early Detection, and Management of Breast Cancer-Related Lymphedema
Jane Armer, PhD, RN, CLT, FAAN
Sinclair School of Nursing and Ellis Fischel Cancer Center, University of Missouri, Columbia, MO, USA

2:50-3:10 Health Information Technology (IT) to Promote Patient-Centered Care
Mei R. Fu, PhD, RN, FAAN
Rory Meyers College of Nursing, New York University, New York, NY, USA

3:10-3:30 Cancer Registry and Electronic Medical Record Data In Head and Neck Cancer Research
Janet Van Cleave, PhD, MSN, RN
Rory Meyers College of Nursing, New York University, New York, NY, USA

3:30-3:35 Assessment of Head and Neck Lymphedema with Ultrasonography
Jie Deng, PhD, RN, OCN, FAAN
School of Nursing, Vanderbilt University, Nashville, TN, USA
Mobile Platform for Assessment, Early Detection, and Management of Breast Cancer-related Lymphedema

Jane M Armer, PhD, RN, FAAN, CLT
Kyung-Min Han, PhD
Nathan C. Armer, MEd
Guilherme DeSouza, PhD

1 Sinclair School of Nursing
2 Dept. of Electrical and Computer Engineering
Outline

- Introduction
- Background
- Proposed System
- Results
- Future Work/Conclusion
LYMPOEDEMA:
Mobile
Platform for at
Home
Observation
Early-
Detection and
Management of
LYMPHOEDEMA
Secondary Lymphedema

- Disruption or obstruction of lymphatic pathways
- Caused by cancer treatment: surgery, radiotherapy or chemotherapy
- 2.9 million at risk (US) 15-54% by 2 years after surgery (Norman et al., 2009)
- Debilitating and distressing even in early stages
- Frequent visits to a specialist beyond the requirement for cancer treatment

Early detection of lymphedema is vital to maximizing a patient’s quality of life (NLN, 2011).

Early detection leading to early treatment could reduce the lifetime cost of treatment by 40+% (Chance-Hetzler et al., 2015).

Accurate detection of lymphedema depends on both limb volume and symptoms (Armer & Stewart, 2005).

Until now, the capability for a patient to self-monitor limb volume change has been limited.


Background

Limb Volume Measurement: “Gold standards”
<table>
<thead>
<tr>
<th></th>
<th>Water Displacement</th>
<th>Circumference</th>
<th>Impedance</th>
<th>Perometry</th>
<th>DEXA Scan</th>
<th>Our Method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost</strong></td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Time to Operate</strong></td>
<td>Moderate-High</td>
<td>Moderate</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Inter-Rater Disparity</strong></td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Pre and Post Maintenance</strong></td>
<td>High</td>
<td>Low</td>
<td>Moderate</td>
<td>Moderate</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Local Measures</strong></td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Self-monitoring Home/Travel</strong></td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Figure 1*
Our method:

- Allows for at-home monitoring of limb volume by patient and/or caregiver.
- Uses ubiquitous smart phones for video and gyro measurements
- Analysis is done on our Mizzou servers

This is ideal for patients in developing countries or those for whom traditional (in-clinic) prospective surveillance is economically unfeasible or geographically impractical.

It can empower all patients in their own self-care.
Proposed System (Client Side)

The helper uses a smartphone.

The patient wears a tattoo sleeve.

The helper shoots a video (The patient holds her body steady).

When internet becomes available, the video is uploaded to the MU project server by email or Dropbox. That is it!
Why do we need tattoo sleeves?

We need tattoo sleeves in order to extract and match many point features from images.

This way, we can expect robust and stable 3D reconstruction.
Proposed System (Server Side)

Extract Images from Video

2D Feature DB

- Key Point Match Full
- Frame Clustering
- Local S&M Reconstruction
- Incremental Gluing of SGMs

Global TRBA

Recovering Remaining Cams

Full BA (SBA)

3D Structure DB

Run SfM pipeline

update
feed in
Results

Sparse Reconstruction: By our method

Dense Reconstruction: By PMVS*

*Y. Furukawa and J. Ponce, “Accurate Dense Robust Multi-View Stereopsis”, TPAMI pp 1362~1376
Results

Input Sequence

Sparse Reconstruction

Dense Reconstruction
Results

Input Sequence

Dense Reconstruction
Results

Input Sequence

Dense Reconstruction

Dense Reconstruction
Limb Volume Measurement

RGB image

3D point clouds

Mesh model

We measure volume of the arm from this model
## Lew's Volume Measurement

### Reliability data

<table>
<thead>
<tr>
<th></th>
<th>Water-displacement</th>
<th>Kinect-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (ml) ± std (ml)</td>
<td>1560.06±387.01</td>
<td>1578.13±367.99</td>
</tr>
<tr>
<td>Pearson Correlation Coefficient</td>
<td>N/A</td>
<td>0.98</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Perometry</th>
<th>Kinect-based</th>
<th>Smart-Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (ml) ± std (ml)</td>
<td>1241.51±262.90</td>
<td>1244.17±265.06</td>
<td>1285.65±268.14</td>
</tr>
<tr>
<td>Pearson Correlation Coefficient</td>
<td>N/A</td>
<td>0.98</td>
<td>0.97</td>
</tr>
</tbody>
</table>

Figure 2: Two Statistical Tests performed between Water-Displacement and the Kinect-based system

Figure 3: Two Statistical Tests performed between Perometer and both systems
Future Work

- Continue beta tests with data collected from other testing sites
- Further improve the algorithm, if needed
- Eliminate the camera calibration procedure (Use EXIF tags)
- Further test the ability to detect localized swelling
- Continue to study the intra- and inter-rater reliability of the measurements
- Make software available to public
In this research, a completely automated and robust system for 3D imaging of human arms is presented.

Our method out-performs existing methods in many aspects, including cost, maintenance, and ease of use, while they maintain high correlation with the “gold standards.” Such performance of the proposed method was demonstrated by exhaustive tests with healthy people, as well as patients with lymphedema.

We will continue to assess the ease of use by patients with variable levels of comfort with technology.
Conclusion

Knowledge is POWER!

The LYMPHOEDEMA project is about making accurate information more readily-accessible to an increased number of patients, care-givers, clinicians, and policy-makers.

The end result will be to empower patients to monitor for changes in their limbs and provide actionable data to clinicians for real-time intervention and management.
References


