Digital Twin for Precision Health

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Financial disclosures: None
My background

• Clinical role: heart failure (HF) cardiologist in Tucson Veterans Affairs Medical Center
  • Clinical management of HF and general heart conditions
  • User of video telehealth to support patients in rural AZ
  • User of population dashboards to manage HF
  • Not focused on procedures or imaging; not using ML yet

• Research role: Clinical cardiovascular research, ASU

• Experience in pharmaceutical utilization management, CVS Health
My background – Research focus

• Epidemiology, outcomes, and prediction of cardiac amyloid in U.S. Veterans
  • Cardiac amyloid due to protein buildup in heart; 10% of HF patients
  • Emerging cause of cardiac and neurologic disease
• Implementation science to promote early diagnosis of amyloid
  • Development of screening interventions
  • Qualitative research - Focus group, interviews

‘Nudge’ interventions to increase adoption of treatments for HF
  • Behavioral nudges frame information without limiting autonomy (e.g., information alert, peer comparison)
FIGURE 1. Impact of AI at multiple levels along the value chain of diagnostic imaging.
AI for Image Processing and Reporting is Robust.
ARCHES
The Data & Analytics Development, Testing & Validation Platform

Amanda Purnell
Nov 2022

Critical Feedback and support from:
Angela Gant-Curtis, Michael Harry, Blake Henderson, Arash Harzand
What is ARCHES?

- The cloud-native platform, complete with a rich set of computational tools, provides a **development, testing, and validation** environment for VA employees and partners.
- In addition to real patient data, Arches makes **synthetic patient data** readily available as a reliable and accurate alternative.
Tools

- Model Training
- ML Applications
- Big Data Analytics
- Dev Tools for Data Scientists
- ETL Tools for Data Engineers

Features

- Streaming
- Data Exploration
- Orchestration
- Identity & Role Based Access
- Integration Potential
What ARCHES Offers

**Freedom to Explore Data Driven Solutions**
ARCHES' ‘walled playground’ design philosophy provides users unequaled freedom to solve problems within the platform.

**Data Access & Flexibility**
Users can leverage existing data sets, synthetic data, or bring in data and use analytics tools to test commercial value.

**Integration Potential**
Containerization allows proven models and data driven research to be migrated to production platforms or reproduced in other systems.
Increasing access: self-service and synthetic data

Organize patient data

Facilitate data insights

Generate sharable synthetic data
What’s on the Menu?

Synthetic Data
- C. Difficile (C-DIFF)
- Suicide Prevention Grand Challenge
- COVID Modeling Challenge
- Heart Failure
- Alzheimer’s
- Cardiac Amyloidosis
- Frailty
- Virtual BP

Leveraging Synthetic Data
- DICOM
- E-Screening
- Suicide Hotline Data
- CCPI Dental

Data Sources

Adding New data Sources
- MDClone
- ADAMS
- NLP Studio
- Cloudera
- AgileMD
- eCART

Applications/Projects
- Cogitativo
- ETS
- SymphonyAI
- HyperScience
- OpenShift
- SIC

- SSIE
- CareCentra
- Alteryx
- TIBCO
- H20 AI
- CCPI

Applications

Applications

Applications
Leveraging Synthetic Data

- VHA Accounts: 75
- VHA Users Provided Training: 35
- VHA Active Studies: 11

- Telehealth
- Sleep Apnea
- Alzheimer’s
- Cardiac Amyloidosis
- Heart Failure Prediction
- Suicide Prevention
- Preventable Clinical Trial
- COVID Variations
- Virtual BP Visits
- Sarcoidosis
- Spinal Stenosis
- Long COVID
- Lung Cancer
Cardiac Amyloid is a Rare, Nonspecific Disease and Potential Candidate for Machine Learning

Early diagnosis is critical in cardiac amyloid: Red flags often predate diagnosis by years
Cardiac Amyloid Research

• Describe incidence and prevalence of disease in entire VA population
  • From 25 million, we identified 14 million between 2012-2022
  • VA Data warehouse (via MDClone): Diagnosis, labs, utilization, medications, demographics
  • Not utilizing: ECG, images, unstructured data

• Develop a predictive model of future cardiac amyloid at time of HF diagnosis

• Next steps:
  • Explore use of ML to discover new predictors, prognosis
  • Develop decision support / nudge interventions to facilitate early diagnosis

Advantages: No SQL coding required using MDClone; rapid access to complete, original data
Clinical Translation:
Pre-symptomatic diagnosis (population health)

• How many patients could have this disease in my health system?
• What is the likelihood of an individual patient having the disease?
• For patients with these characteristics what is the cost effectiveness of screening based on my health system?
• Who is falling through the cracks / no show?
• Who needs a phone call checkup?
Clinical Translation
Initial presentation of HF Patient

• Does this patient truly have HF?

• What is the underlying, causative disease?
  • e.g., sarcoid heart disease

• Prognosis?
  • Personalized risk: How much will defibrillator reduce risk for this patient?
  • Do we need a continuous risk predictor or static?

• What diagnostic information is missing, needed?

• What treatments are missing compared to similar patients?

• What is the most efficient pathway to diagnose in my health system?
  • E.g., centers preferring invasive strategy have quicker time to diagnosis
Clinical Translation
6-month Follow up of same HF patient

• Compared to similar patients in my health system, should treatment be changed?
• Was the diagnosis correct?
• What is the prognosis at this time point?
• What test should I order now?
  • E.g. repeat echocardiogram, renal function

Much of daily clinical practice behavior guided by consensus, expert guidance, experience and not data
Is a digital twin applicable at the level of a health system / population?

<table>
<thead>
<tr>
<th>Components of digital twin</th>
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<tbody>
<tr>
<td>Computational model</td>
<td>Yes</td>
</tr>
<tr>
<td>Represent behavior of physical system/process</td>
<td>Yes – entire population is the ‘system’</td>
</tr>
<tr>
<td>Two-way flow of information</td>
<td>Yes ?</td>
</tr>
<tr>
<td>Physiological model</td>
<td>No</td>
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</tbody>
</table>

At health system level, improve processes for staff allocation, visitor/patient flow, waiting time, equipment and other internal resource provision, emergency vehicle access and other service-related operations
Challenges

Fig. 4 Translation issues in digital twin science.
Perils of Big Data – Google Flu Trends

Perils of Big Data – Google Flu Trends

• Even 3-week-old CDC data do a better job of projecting current flu prevalence than GFT

• Several changes in Google’s search algorithm and user behavior likely affected GFT’s tracking
  • This could happen with digital twin

• Recommendations:
  • Transparency and duplication
  • Use Big Data to Study the Unknown

Challenges of Technology Integration:
Despite Promise of Remote Monitoring, Clinicians May View as Extra Burden

Can remote monitoring talk back? Prescribe and Predict
Challenges

• Clinician and patient behavior change is difficult
• Clinicians are overworked, often with low-value work
  • E.g., additional alerts / nudges in EMR system will trigger clinician pushback due to information overload / burnout
• Digital twin designed for a repeated workflow that reduces clinician workload is easier to adopt
  • E.g., coronary CT angiography flow assessment (CT FFR) for severity of stenosis; pulmonary nodule detection

Who benefits from the innovation and are they included in some way?
## Application Drivers

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
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<tbody>
<tr>
<td>What would you see as most important application drivers?</td>
<td>Integration of health care data silos, interoperability, incremental progress, implementation science (e.g., workflow), behavior</td>
</tr>
<tr>
<td>What actionable information do you see DT can provide that is not feasible today?</td>
<td>Real-time updates, address different problems within a single platform, use all available data and make actionable insights</td>
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## Technical gaps and opportunities

<table>
<thead>
<tr>
<th>Technical gaps?</th>
<th>External generalizability; as an emerging field, the digital twin needs guidelines, gold-standards, and benchmark tests (e.g., MINIMAR)</th>
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<tbody>
<tr>
<td>How would you see your work or the work of the community to contribute to this? Modeling, Sensor Design, AI or other matters?</td>
<td>Implementation science- (reach, implementation, effectiveness, adoption, maintenance)</td>
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## Teaming and timeline

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<tbody>
<tr>
<td>What kind of team would you expect to address the technical challenges?</td>
<td>Don’t forget ethics, real-world clinicians, social science / qualitative, geriatrics, implementation scientist</td>
</tr>
<tr>
<td>What disciplines?</td>
<td></td>
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<tr>
<td>What is the timeline for your potential directions? 2 years, 5 years or</td>
<td>2 years with focus on ML models in cardiac amyloid</td>
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<td>10 years?</td>
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