The Future is Now: Practical Applications for Advanced Technology

Mas Takashima, MD
Chairman
Department of Otolaryngology – Head & Neck Surgery
Thank You
Your Cybertruck Order is Confirmed

YOUR CYBERTRUCK
Dual Motor AWD
Full Self-Driving Capability

ORDER NUMBER
RN112787345
"Oh my f__ing God! The glass stunt went fine in rehearsal" – Elon Musk
Panelists

• David Friedland, MD – MCW
  – Artificial intelligence and otolaryngology

• Jim Denneny, MD – AAO – HNS
  – Reg-ent, your practice and data driven medicine
Panelists

• David Friedland, MD – MCW
  – Artificial intelligence and otolaryngology
• Jennifer Long, MD – UCLA
  – Innovative medicine in otolaryngology
• Davud Sirjani, MD – Stanford University
  – Telemedicine in otolaryngology
• Eric Genden, MD – Mount Sinai
  – How do you promote innovative ideas at the Individual/Department/Institutional level
Panelists

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• **Davud Sirjani, MD – Stanford University**
  – Telemedicine in otolaryngology

• **Eric Genden, MD – Mount Sinai**
  – How do you promote innovative ideas at the Individual/Department/Institutional level

• **Mas Takashima, MD – Houston Methodist**
  – Institutional level interest and implementation of new technology in patient care
The future is now:
Artificial intelligence and otolaryngology

David R. Friedland MD PhD
Medical College of Wisconsin
Milwaukee, WI
• Autonomy: perform tasks without constant user guidance

• Adaptivity: improve performance by learned experience

Are these AI?
• Autonomous car
• GPS navigation
• Netflix movie suggestions
• Gallup poll analyses

Artificial Intelligence
Machine Learning
Natural Language Processing
Image Recognition
Robotics
### Machine Learning

**Supervised**
- Regression
- Decision tree
- Random forest
- Classification
  - Naïve-Bayes
  - Trees
  - SVM
  - KNN
  - Logistic Regression
- ANN

**Unsupervised**
- SVD
- PCA
- K-means
- Apriori
- FP-growth
- Hidden Markov Model
- ANN

**Reinforcement**
- Positive
- Negative
Basic Rules of Reading a CT
Sinusitis? Basic rules and a goal

UNCATEGORIZED
Much of this in basic sciences (e.g., cancer detection, interpretation of genomics)
Decoding phonation with artificial intelligence (DeP AI): Proof of concept

- Used Keras open source deep-learning library
- Used a binary outcome (nl vs. abnl)
- Better on training than on validation set
  - Overfitting
- Better with some disorders than others
Machine Learning Diagnosis of Peritonsillar Abscess.

Wilson MB¹, Ali SA¹, Krywacz KJ¹, Smith JD¹, Hoff PT¹.

Author Information

¹Department of Otolaryngology-Head and Neck Surgery, University of Michigan, Ann Arbor, Michigan, USA.

Table 1. Performance Measures of Machine Learning Algorithms.

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Accuracy (95% CI)</th>
<th>Sensitivity (95% CI)</th>
<th>Specificity (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artificial neural network</td>
<td>0.72 (0.68-0.76)</td>
<td>0.86 (0.77-0.95)</td>
<td>0.50 (0.35-0.65)</td>
</tr>
<tr>
<td>Random forest</td>
<td>0.71 (0.66-0.75)</td>
<td>0.74 (0.65-0.82)</td>
<td>0.66 (0.55-0.76)</td>
</tr>
<tr>
<td>Logistic regression</td>
<td>0.71 (0.66-0.76)</td>
<td>0.77 (0.69-0.88)</td>
<td>0.62 (0.51-0.73)</td>
</tr>
</tbody>
</table>
Development of a Statistical Model for the Prediction of Common Vestibular Diagnoses

David R. Friedland, MD, PhD; Sergey Turms, PhD; Christy Erbe, BS; Alexis Miles, MPT

**Importance**
Treatment of patients with vestibular disorders can be complex, requires lengthy clinic visit time, and uses greater clinical resources for diagnosis. A pre-encounter intake questionnaire may predict the most common disorders, allowing for more efficient allocation of resources and use of clinicians.

**Objective**
To develop a statistical model for predicting vestibular diagnoses, prior to clinical evaluation, from an intake questionnaire.

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Direct-to-Patient Survey for Diagnosis of Benign Paroxysmal Positional Vertigo

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**Abstract**
Given the high incidence of dizziness and its frequent misdiagnosis, we aim to create a clinical support system that identifies the presence or absence of benign paroxysmal positional vertigo with high accuracy and specificity. This paper describes a phase study currently underway for classification of benign paroxysmal positional vertigo, which includes diagnosis by a clinician in a clinical setting. Patient background information is collected by a survey on an Android tablet and machine learning.

**Related Work**
Several approaches have been taken to classify vestibular disorders, and BPPV specifically. A linear predictor was created by Friedland et al. [1] after identifying the most statistically relevant features ($p < 0.02$) from a 10-page patient intake questionnaire.
Otoscopic diagnosis using computer vision: An automated machine learning approach.

Livingstone D¹, Chau J

Author information

1 Division of Otolaryngology-Head and Neck Surgery, Department of Surgery, University of Calgary, Calgary, Alberta, Canada.

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Correct</th>
<th>Subthreshold Diagnosis</th>
<th>Incorrect Diagnosis</th>
<th>Algorithm %</th>
<th>Physician %</th>
<th>Physician Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute otitis media</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>80.0</td>
<td>24/30</td>
</tr>
<tr>
<td>Cerumen</td>
<td>9</td>
<td>1</td>
<td>0</td>
<td>90.0</td>
<td>74.0</td>
<td>74/100</td>
</tr>
<tr>
<td>Cholesteatoma</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>50.0</td>
<td>55.0</td>
<td>11/20</td>
</tr>
<tr>
<td>Exostoses</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>70.0</td>
<td>14/20</td>
</tr>
<tr>
<td>Myringitis</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>36.7</td>
<td>11/20</td>
</tr>
<tr>
<td>Myringosclerosis</td>
<td>8</td>
<td>1</td>
<td>0</td>
<td>88.9</td>
<td>38.9</td>
<td>35/90</td>
</tr>
<tr>
<td>Normal</td>
<td>11</td>
<td>0</td>
<td>Myringosclerosis</td>
<td>84.6</td>
<td>64.6</td>
<td>84/130</td>
</tr>
<tr>
<td>Otitis externa</td>
<td>8</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td>37/90</td>
</tr>
<tr>
<td>Otomycosis</td>
<td>0</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>4/10</td>
</tr>
<tr>
<td>Serous otitis media</td>
<td>9</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>44/100</td>
</tr>
<tr>
<td>TM perforation</td>
<td>6</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td>46/70</td>
</tr>
<tr>
<td>TM perforation</td>
<td>8</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>37/90</td>
</tr>
<tr>
<td>Tympanostomy tube (extruded)</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>80.0</td>
<td>24/30</td>
</tr>
<tr>
<td>Tympanostomy tube (in position)</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>95.0</td>
<td>76/80</td>
</tr>
<tr>
<td>Overall</td>
<td>79</td>
<td>6</td>
<td>4</td>
<td>88.7</td>
<td>58.9</td>
<td>524/890</td>
</tr>
</tbody>
</table>

Algorithm: 88.7%
Physician: 58.9%
3D Image Analysis for Staging Chronic Rhinosinusitis

Sooyoung Lim, Michael Ramirez, Jonathan C. Garneau, Megan K. Ford, Katherine McKeough, Daniel T. Giri, Fuad M. Baroody, Samuel G. Armato, III, and Jayant M. Pinto

Author information

The publisher's final edited version of this article is available at Int Forum Allergy Rhinol
See other articles in PMC that cite the published article.
Unique Clinical Language Patterns Among Expert Vestibular Providers Can Predict Vestibular Diagnoses

*Jake Luo, †Christy Erbe, and ‡David R. Friedland

*Department of Health Informatics and Administration, University of Wisconsin - Milwaukee; and †Department of Otolaryngology and Communication Sciences, Medical College of Wisconsin, Milwaukee, Wisconsin

Objective: To identify novel language usage by expert providers predictive of specific vestibular conditions.

Study Design: Retrospective chart review and natural language processing. Level IV.

Setting: Tertiary referral center.

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<table>
<thead>
<tr>
<th>TABLE 3. Top 10 features positively associated with specific diagnoses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anxiety Related Dizziness</strong></td>
</tr>
<tr>
<td>Lightheadedness</td>
</tr>
<tr>
<td>Had chronic dizziness</td>
</tr>
<tr>
<td>Denies true vertigo</td>
</tr>
<tr>
<td>Intermittent headaches</td>
</tr>
<tr>
<td>Ear infection</td>
</tr>
<tr>
<td>Constant pressure</td>
</tr>
<tr>
<td>Multiple otologic</td>
</tr>
<tr>
<td>Bilateral ringing</td>
</tr>
<tr>
<td>Frontal headaches</td>
</tr>
<tr>
<td>Disconnectedness</td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>TABLE 4. Results of Naïve Bayes algorithm for classifying subjects into one of four vestibular diagnostic categories</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conditions</strong></td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>Anxiety</td>
</tr>
<tr>
<td>BPPV</td>
</tr>
<tr>
<td>Central Vestibular Disorder</td>
</tr>
<tr>
<td>Vestibular Migraine</td>
</tr>
<tr>
<td>Average</td>
</tr>
</tbody>
</table>
- **Kiroku's** sophisticated natural language system can pick up context in a conversation between you and the patient and automatically write your clinical notes for you.
- **MDOps** dramatically reduces the documentation time with you dictating and filing clinical notes using your iPhone or iPad, allowing you to spend more time with more patients.
- **Notable** uses wearable tech, voice interface, and artificial intelligence to enrich every patient-physician interaction.
- **Saykara** is simplifying data capture with a new artificial intelligence-based virtual scribe solution that eliminates the hassle of working with EHRs.
- **Sopris Health** is an intelligent clinical operations platform offering a pioneering A.I. medical scribe technology to tackle clinical inefficiencies.
- **Suki** is a digital assistant for doctors that starts by helping lift the burden of medical documentation.
- **Tenor.ai** is an automated medical scribe that listens to your patient visits via a small microphone in the exam room and creates an accurate patient note in real time.

MobiHealthNews Aug 2018
- Scheduling
- Billing
- Care pathways
- Clinical decision support
  - Diagnosis, test interpretation, monitoring
- Disease prediction
- Surgical planning
- Surgery
Innovative Medicine in Otolaryngology

Jennifer Long, MD, PhD
Department of Head and Neck Surgery
UCLA David Geffen School of Medicine
and Greater Los Angeles VAMC
Physician must insert wisdom to medicine and medicine to wisdom.

-Hippocrates
How we got to now
Big data: Immune markers

1960s: organ transplants usually failed

> Select the right organ donor based on the patient’s serum

Now: At least 1374

Paul Terasaki, UCLA
Initial sequencing and analysis of the human genome

International Human Genome Sequencing Consortium *

* A partial list of authors appears on the opposite page. Affiliations are listed at the end of the paper.

The human genome holds an extraordinary trove of information about human development, physiology, medicine and evolution. Here we report the results of an international collaboration to produce and make freely available a draft sequence of the human genome. We also present an initial analysis of the data, describing some of the insights that can be gleaned from the sequence.
Even bigger data

articles

Initial sequencing and analysis of human genome

International Human Genome Sequencing Consortium

The human genome holds an extraordinary store of information about human development, physiology, morbidity and mortality. Here we report the results of an international collaboration to produce and make freely available a draft sequence of the human genome. We also present an initial analysis of the data, describing some of the insights that can be gleaned from the sequence.
Where we are now
ADA-SCID - universally fatal gene mutation

> Correct the patient’s own hematopoetic stem cell genes

100% survival (n=78)

Don Kohn, UCLA

1. Anti-tumor antibodies

2. Antibodies to un-inhibit host immune cells

3. Immune cell modulation

By Simon Caulton - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=29559885
What’s next
Human genome sequenced

2001

CRISPR-Cas9

Gene edits in cell lines published

2013

"CRISPR babies"

First humans born from gene-edited embryos

Nov 2018

Deafness edits?

Plan for embryo gene editing for Connexin-26 mutation

Aug 2019

Guidelines?

International Consensus meeting planned

2020

A brave new world
Allergy and immune dysregulation

Carcinogenesis

Microbiome

Voice production and perception
The future is now: Practical applications using advanced technology

How do you promote innovative ideas at the Individual/Department/Institutional level

- Eric M. Genden, MD, MHA
- The Isidore Friesner Professor and Chairman
- Otolaryngology- Head and Neck Surgery
- Senior Associate Dean for Clinical Affairs
- The Icahn School of Medicine at Mount Sinai
Foster a culture that embraces creative ideas

Recruit faculty that are creative and enjoy mentoring

Provide an infrastructure to support innovation

Decide when to invest in innovation
We should be seeking innovation that improves care, lowers cost, and provides an efficiency.
“Health care economists estimate that 40–50% of annual cost increases can be traced to new technologies or the intensified use of old ones.”

“That makes the control of technology the most important factor in bringing costs down.”

Daniel Callahan, “Health care costs and Medical technology,” in From Birth to Death and Bench to Clinic: The Hastings Center Bioethics Briefing Book for Journalists, Policymakers, and Campaigns, ed. Mary Crowley (Garrison, NY :The Hastings center, 2008), 79-82.
• To achieve responsible innovation, we approach it through a research framework.

• We partner with the Dean and the medical school.

As an AMC, our responsibility is to study innovative ideas before promoting them.
Research project
Research Council

- New projects/Innovation/Ideas
- Collaborative review and critique
- Series of recommendations

Clinical trials
Basic science
Clinical science
Statistics
App development

Technology
Health policy
Data scientist
Ad hoc members
Review \rightarrow \text{Optimize} \rightarrow \text{Investment}

- Radiology
- Neuroscience
- Genomics
- Medical education
- Biomedical engineering
- Rapid Prototyping Center
- Computer modeling
1. Establish an departmental infrastructure that encourages responsible innovation.

2. Meaningful innovation requires an institutional commitment to the process.
The Future is Now: Institutional level interest and implementation of technology in patient care

Mas Takashima, MD
Chairman
Department of Otolaryngology – Head & Neck Surgery
INNOVATION
It drives everything we do.

Learn More
Houston Methodist Center for Innovation is the research-and-development engine for technology-enabled transformation into medicine:

- Fostering a culture of innovation
  - Clinical
  - Research
  - Education
  - IT
  - Admin
  - Supply chain
  - Marketing
  - Billing
- Case studies
- Being quick to embrace/quick to fail
Houston Methodist Center for Innovation developed a laboratory environment for testing technology. The Technology Hub provides an environment from wellness to acute medicine.

The Center for Innovation is prioritizing three rooms to start:

- Voice technology and natural language processing.
- Biometrics.
- Virtual reality (VR) waiting room.

Goal is to provide a space where the technology can be designed around real provider- and patient-use cases.

- Hub to vendor partners and researchers who want to collaborate in the development of new health technologies.
- Amazon Alexa - voice assistant
- Apple - Apple Health Record
- Appriss Health - prescription drug monitoring programs (PDMP) integration to Epic, opioid decisions support tool
- Blockit - RPA B2B referrals
- Buoy Health - automated diagnostic artificial intelligence (AI)
- Centers for Disease Control - opioid 12 recommendations
- Digital Bridge
- Fitbit - application programming interface (API) connection
- Identifi (Evolent) - managed security service provider (MSSP) tech Eco system
- Illumicare - clinician efficiency, puts clinical information front and center
- Lastpass - enterprise password security and automation
- Nokia - API connection
- Paradox Olivia - digital hiring assistant
- PatientPing - MSSP tech eco system
- Phunware - mobile app, wayfinding
- Recondo - AI consumer estimates
- Well Health - patient messaging
- WorkFusion - RPA

Case Studies
- CareSense >
- Chatbot (Mia) >
- Digital Bridge >
- Health Records on iPhone >
- Natural Language Processing >
- Opioid Methodology >
- Patient Biometrics >
- Price Estimation >
- Robotic Process Automation >
- Smart Ribbons >
- Technology Hub (Lab) >
- Virtual Health >
- Wayfinding >
- WELL Health Communications >
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- Wayfinding
- WELL Health Communications
Burnout Pod Trial
3D Endoscopy
3D Robotic Systems
3D Exoscopes
MANTIS HVS

Mantis FlexCam

Mantis Glasses

Electronics Pack

Whatever cameras are pointing at – that’s what the surgeon sees in 3D real-time!

Move neck across table to view any surgical site
Tele-surgery?

Live remote consultation

Remote specialist surgeon can consult operating surgeon through earpiece/speakerphone real-time with the same view operating surgeon is getting through Mantis.

Local procedure

Operating surgeon’s view through Mantis

APPLICATIONS 1) Rural hospitals w/ limited surgeon coverage (e.g. VA), 2) training/education centers, 3) private office exam rooms