Natural Language Dialogue Systems using AI and ML

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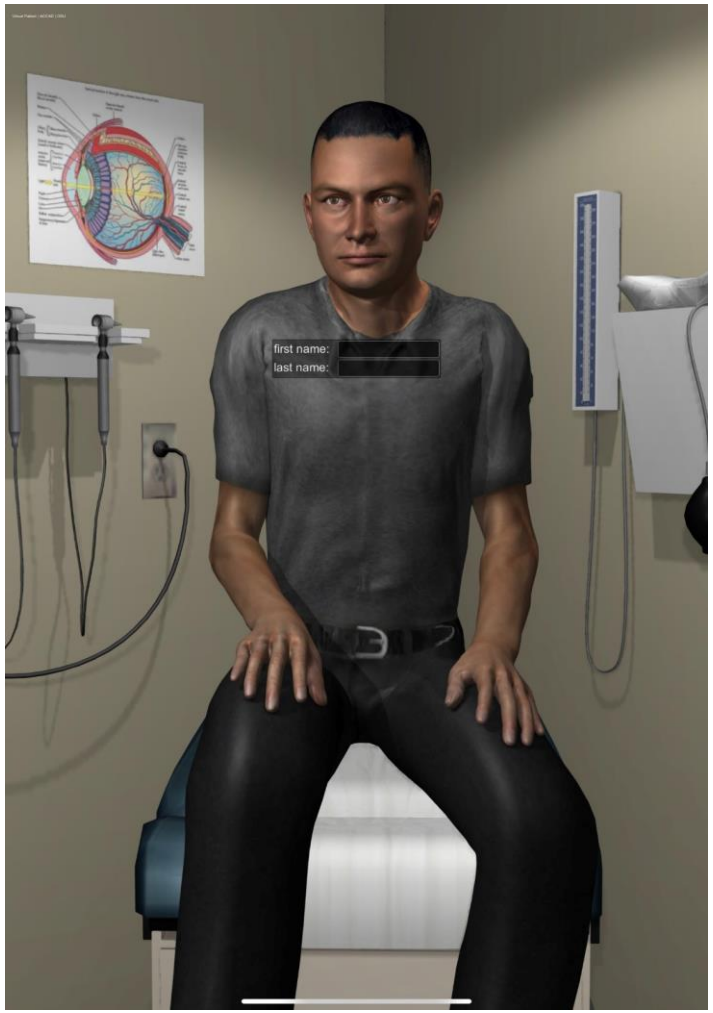
Wexner Medical Center

Improving People's Lives
through innovation in research, education and patient care

virtual

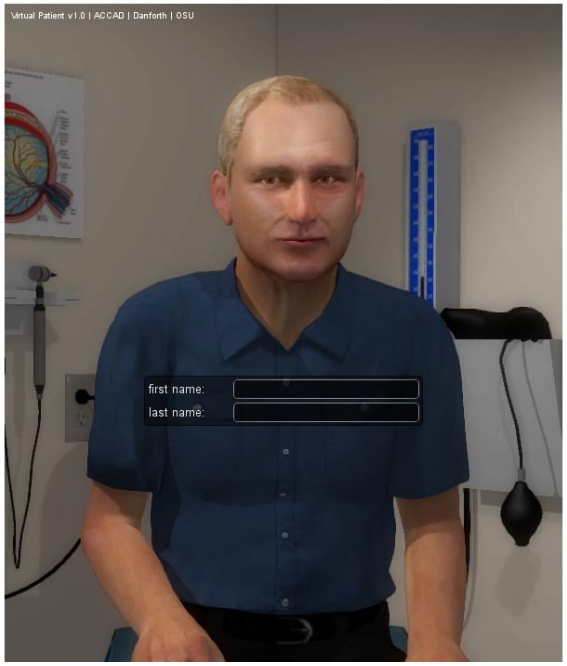
Virtual Patient



- Artificial Intelligence - simulate “real” patient
- Conversational – can understand and respond to student questions
- Provide immediate feedback – students can practice multiple times

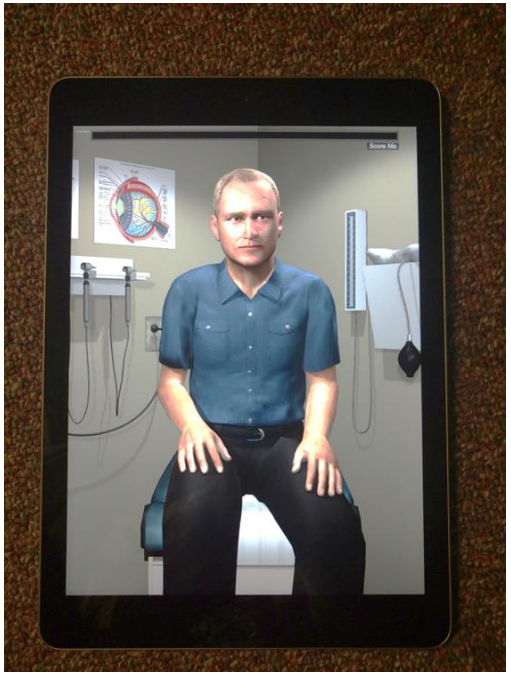
Virtual Patient

Web-based
chatted conversation



Clinical Skills Center
Spoken conversation
(Dragon)

iPad
Spoken conversation
(Watson)



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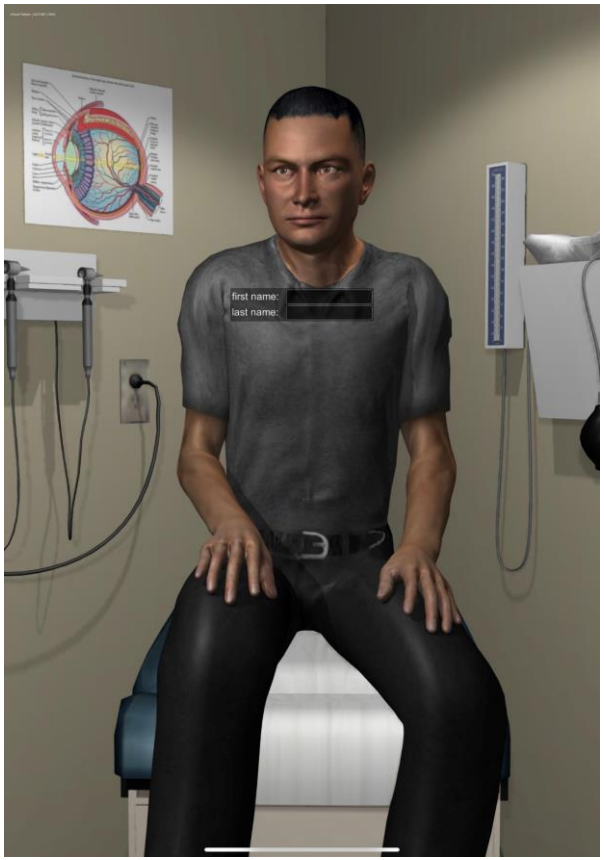
Natural Language Understanding

- Input type
  - Typed or spoken
- Question identification
  - Rule based vs ML/NLU
- Output
  - TTS vs pre-recorded



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Dialogue Management

Input type

Chatted (typed)

- Questions are more succinct
- Conversations shorter
- Typos considerable

- *“Waht brings you in today?”*
- *“When did hte pain start?”*
- *“Anything besieds the back pain?”*
- *“Tell me more.”*

Spoken (STT)

- Questions are much longer
- Multiple questions in one query
- Conversations longer
- Typos not important
- STT mistranslations important

- *“So I'd be probing seems to help so that's good and so you started you said this began about 4 to 5 years ago you had another episode.”*
- *“Are you generally happy with your life now? your job? house?”*

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Question Identification

Rule based (pattern matching)

- Based on NLP Software ChatScript
- Initial NLP Processing (spell checking, canonization, POS tagging, etc)
- State aware – pronoun resolution
- ~3,000 rules to manage dialogue

ChatScript

Dialogue organized by History of Present Illness, Past Medical History, Family History, Social History

```
#! What brings you in today
u: What_brings_you_in_today (["what brings you" "why are you"] in today)  ^factanswer("I'm hoping you can help me out with a problem I've been having.")
u: (![when other else] [why what] * ["do for" bring help come] * [today tonight evening afternoon morning day]) ^reuse (What_brings_you_in_today)
u: (![when other else] "what brings you in") ^reuse (What_brings_you_in_today)
u: (![when other else] "what brings you in today") ^reuse (What_brings_you_in_today)
u: (![when other else] "what brings you here") ^reuse (What_brings_you_in_today)

#! Any other problems
u: Any_other_problems1 (any other problems)  ^factanswer("I don't believe so.")
u: (!health !medical << [other else] [symptom issue concern problem "bothering you" discuss] >>) ^reuse (Any_other_problems1)
u: (!try anything else) ^reuse (Any_other_problems1)

#! Are you taking any medication for the 1 $chiefcomplaint=1
u: Taking_medication_for_the_1 (are you taking any medication for the $chiefcomplaint?)  ^factanswer("I don't take any medications.")
u: (![how long other] [use take on try] * [alleviate get_rid_of reduce diminish "help with" for] *~2 [~itwords $chiefcomplaint?]) ^reuse (Taking_medication_for_the_1)
u: (![how long other] [use take on try "no"] * ~medicines * [~itwords $chiefcomplaint?]) ^reuse (Taking_medication_for_the_1)
```

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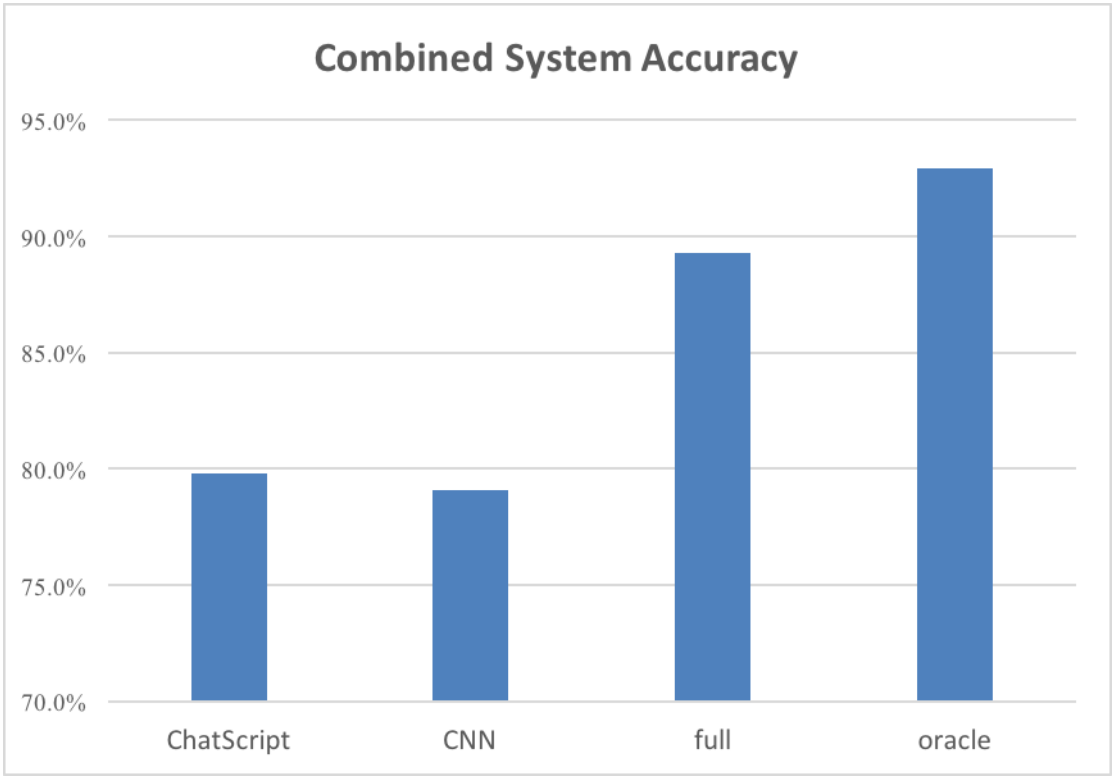
Dialogue Accuracy

Dialogue Type	Typed
Type of Case	Simple
Type of History	Complete
Students	First Year (n=21)
Total questions asked	1396
Answered correctly	83%
Answered incorrectly	6.4%
Not answered	10%

Dialogue accuracy improvements with ML/NLU

- Train Convolutional Neural Network analyzer (CNN)
- Used word - and character-based CNNs to identify and classify input questions
- Binary classifier to choose between CNN and ChatScript



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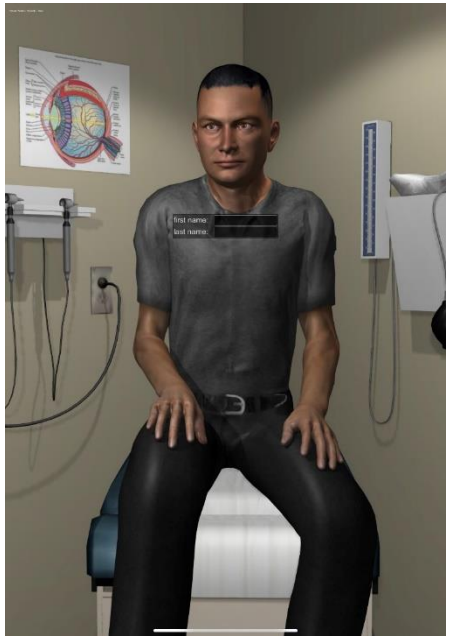
Fall 2018 – Mr. Carlos Martinez

- Practice history taking by first year medical students
- HOPI, PMH, Family History, Social History
- ~200 Conversations
- > 12,000 Questions



	All inputs	Watson Ex (71.4%)	Watson Acceptable (89.5%)	Watson Gibberish (10.5%)
ChatScript Correct	73.5%	78.3%	76.0%	50.2%
CNN Correct	72.7%	74%	73.6%	59.6%
Acceptable Response	76.2%	80.8%	78.7%	53.8%
Question Not Understd	16.5%	11%	11.7%	35.4%

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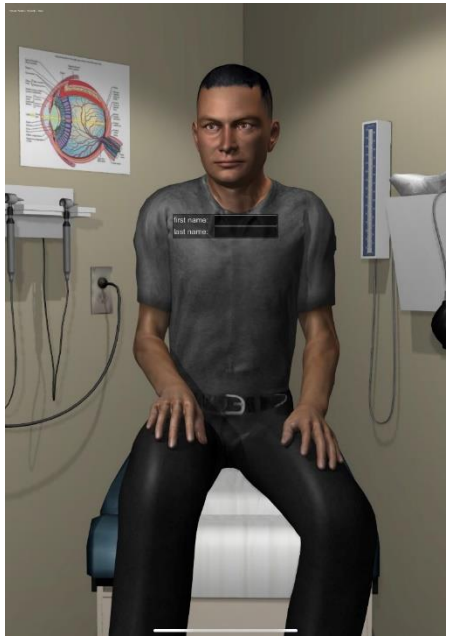

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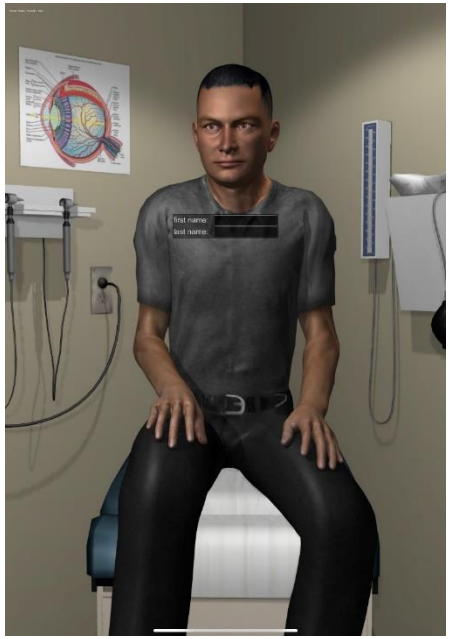

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Word Error Rate					
Microsoft	Google	Watson untrained	Watson Acoustic	Watson Language	Watson Both
0.078	0.053	0.079	0.069	0.058	0.056

Natural Language Understanding

Text-to-Speech

- “Voices” limited
- Quality varies
- Limited inflection
- Somewhat slow

Pre-recorded

- Time-consuming to create
- More difficult to deliver
- Difficult to update or modify
- More realistic

Summary

- Using Natural Language Understanding, Virtual Patients can understand, respond, categorize, and “assess” student performance, enabling students to practice their history taking skills and receive immediate feedback.

- Dialogue management can use fairly simply rule based approaches or more sophisticated NLU systems.
  - Rule based systems require hand crafting rules but can work with limited data.
  - NLU systems can be more robust but require significant training data.
  - Hybrid systems can maximize accuracy.

- Depending on the application, modern cloud-based systems may be easier to implement.

Support

Artificial Intelligence based Virtual Reality (VR) Simulation of Provider-patient interaction to enhance cultural competency using a simulated patient with limited English proficiency. Medicaid Equity Simulation Project $455,103 2018 – 2019

Virtual Patients for Medication Assisted Treatment of Opioid Use Disorder. DHHS Health Resources and Services Administration (Supplement) $100,000 2018 – 2019

Using Automatically Generated Paraphrases and Discriminative ASR Training to Author Robust Question-Answering Dialogue Systems. National Science Foundation $499,904 2016 – 2019

Creating the Complete Virtual Standardized Patient: Integrating Natural Language Ability into Clinical Reasoning Cases to Assess Information Gathering and Clinical Reasoning. The Institute for Innovative Technologies in Medical Education/Med-U $24,250, 2015 – 2019

Virtual Patient Simulations to Assess Data Gathering and Clinical Reasoning National Board of Medical Examiners Edward J. Stemmler Education Research Fund, $149,862, 2012 – 2014

Virtual Patients in the 2012 Curriculum The Ohio State University College of Medicine Innovation Fund, $45,000 2011- 2013

Virtual Reality: A Unique Means to Teach the Reality of the Patient-Centered Medical Home. DHHS Health Resources and Services Administration, $ 1,465,655 2010 – 2015

Development of Virtual Patients using the Second Life platform. Perinatal Resources Inc, $30,000 2008-2011