DAISY: Diagnostic AI System for Robot-Assisted A&E Triage

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TAS Showcase
5th – 6th March 2024
Researchers interacting with DAISY at the University of York's Institute for Safe Autonomy

Research Team

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Georgia Sowerby, Computer Science, University of York, Research Student

Dr Ioannis Stefanakos, Computer Science, University of York, Research Associate

Dr Bev Townsend, Computer Science/York Law School, University of York, Research Associate and Co-investigator
Motivation

- NHS England has a **shortage** of medical staff and an **aging** workforce \(^1\)
- Increased **stress** is leading to sickness absences \(^1\)
- **Distribution** of doctors is not uniform \(^1\)
- Healthcare worker shortages are experienced everywhere
  - shortfall of 124,000 physicians by 2034 in the United States \(^2\)
  - shortage of 1 million healthcare workers in the EU \(^3\)

An Increasing Challenge...

• It takes years to train a clinician
• Yearly intakes are lower than estimated needs
• Alternatives must be explored
Clinicians: What & How?

1. **Teams** to manage **Workload**

2. **Individuals** to drive **Processes**

3. **Neurons** to make **Decisions**
Workload

The Team
The Ideal

Data Gathering and Clinical Decision Making...
The Deficit
Our Solution
Processes

The Individual
The Hospital Triage Process

**Collection of Subjective data**
- **Location:** Reception
- **Personnel:** Admin Staff
- **Outcome:** Zeroth Triage

**Collection of Subjective data**
- **Location:** Triage Room
- **Personnel:** Triage clinician
- **Outcome:** Primary Triage

**Collection of Objective data**
- **Location:** Triage Room
- **Personnel:** Triage clinician
- **Outcome:** Secondary Triage

**Interpretation and Analysis**
- **Location:** Triage Room
- **Personnel:** Triage Clinician
- **Outcome:** Interventions & Investigations

**Examination and Assessment**
- **Location:** Clinician Room
- **Personnel:** Treating Clinician
- **Outcome:** Treatment Plan
The Hospital Triage Process

Collection of Subjective data
Location: Reception
Personnel: Admin Staff
Outcome: Zeroth Triage

Collection of Subjective data
Location: Triage Room
Personnel: Triage clinician
Outcome: Primary Triage

Collection of Objective data
Location: Triage Room
Personnel: Triage clinician
Outcome: Secondary Triage

Interpretation and Analysis
Location: Triage Room
Personnel: Triage Clinician
Outcome: Interventions & Investigations

Examination and Assessment
Location: Clinician Room
Personnel: Treating Clinician
Outcome: Treatment Plan

Innovative User Interface
Peripheral Devices
dAvInci Algorithm
Decision

The Neurons
dAVInci (Diagnostic Algorithm for Intelligent Clinical Intervention)

Demographic  
Anatomical  
Subjective  
Objective
'AI System' Supports 'Whole System'

1. **Teams** to manage **Workload**

2. **Individuals** to drive **Processes**

3. **Neurons** to make **Decisions**
Refined Triage Pathway

1. **Collection of Subjective data**
   - Location: Reception
   - Personnel: Admin Staff
   - Outcome: Zeroth Triage

2. **Collection of Subjective data**
   - Location: Triage Room
   - Personnel: Triage clinician
   - Outcome: Primary Triage

3. **Collection of Objective data**
   - Location: Triage Room
   - Personnel: Triage clinician
   - Outcome: Secondary Triage

4. **Interpretation and Analysis**
   - Location: Triage Room
   - Personnel: Triage Clinician
   - Outcome: Interventions & Investigations

5. **Examination and Assessment**
   - Location: Clinician Room
   - Personnel: Treating Clinician
   - Outcome: Treatment Plan

6. **Collection of Subjective and Objective data**
   - Location: DAISY Room
   - Personnel: DAISY
   - Outcome: Full Triage and Analysis

7. **Confirmation Adjustment of DAISY suggestions**
   - Location: Triage Room
   - Personnel: Triage Clinician
   - Outcome: Interventions & Investigations

8. **Examination and Assessment**
   - Location: Clinician Room
   - Personnel: Treating Clinician
   - Outcome: Treatment Plan
Diagnostic AI System (DAISY)
Technical Solution
Consider the following example for the detection of Meningitis:

\[ \text{dem}(\text{meningitis}, D) = \text{true} \]
\[ \text{anat}(\text{meningitis}, A) = \text{head} \lor \text{neck} \]
\[ \text{subj}(\text{meningitis}, S) = (\text{headache} \land \text{vomiting}) \lor \text{rash} \]
\[ \lor \text{photophobia} \]
\[ \text{obj}(\text{meningitis}, O) = ((T > 37.9 \lor T < 36) \land PR > 90) \]
\[ \lor ((T > 37.9 \lor T < 36) \land RR > 20) \]
\[ \lor (PR > 90 \land RR > 20) \]
DAISY Solution Abstracted
Demonstration

DAISY: A video illustration
Evaluation

1. Medical practitioners' survey

2. Patient and Public Involvement exercise @ York Hospital

3. UK-wide online public study

4. Testing of technical solution (next slides)
Preliminary Evaluation: solution testing

• **Correctness** evaluation
  • Synthetic dataset comprising 6237 patient entries for testing the triage capabilities of our solution
  • 81.74% of the generated reports confirmed as producing correct assessments (16995 out of 20790)

• Issues identified:
  • Multiple terms for similar/same illness
  • Incomplete ruleset and ranking system

Example of multiple terms:
- Pneumonia (Community Acquired)
- Respiratory Tract Infection
- Chest Infection
- Lower Respiratory Tract Infection
Preliminary Evaluation: solution testing

• **Usability** evaluation
  - Invited 12 participants with technical background to use a prototype of the system
  - Used their feedback to improve solution

• Need to invite more users in our usability evaluation from more diverse backgrounds

<table>
<thead>
<tr>
<th>Question</th>
<th>Average Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Evaluating step 1: Inputting information</strong></td>
<td></td>
</tr>
<tr>
<td>I found the DAISY system easy to use</td>
<td>4</td>
</tr>
<tr>
<td>I would probably need the support of a technical person to use this DAISY system part</td>
<td>2</td>
</tr>
<tr>
<td>I felt confident using the DAISY system</td>
<td>3.67</td>
</tr>
<tr>
<td>I thought there was too much inconsistency in the DAISY system</td>
<td>1.92</td>
</tr>
<tr>
<td>I felt frustrated using the DAISY system</td>
<td>2.17</td>
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<tr>
<td>I felt satisfied using the DAISY system</td>
<td>4</td>
</tr>
<tr>
<td>I felt the mental demand for this activity was reasonable and manageable</td>
<td>3.75</td>
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<tr>
<td><strong>Evaluating step 2: Medical equipment</strong></td>
<td></td>
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<tr>
<td>I found the medical equipment easy to use</td>
<td>3.33</td>
</tr>
<tr>
<td>I would probably need the support of a medical equipment</td>
<td>3.42</td>
</tr>
<tr>
<td>I felt confident using the medical equipment</td>
<td>3.33</td>
</tr>
<tr>
<td>I thought there was too much inconsistency in the medical equipment</td>
<td>2.08</td>
</tr>
<tr>
<td>I felt frustrated using the medical equipment</td>
<td>2.08</td>
</tr>
<tr>
<td>I felt satisfied using the medical equipment</td>
<td>3.5</td>
</tr>
<tr>
<td>I felt the mental demand for this activity was reasonable and manageable</td>
<td>3.67</td>
</tr>
<tr>
<td>I felt the physical demand for this activity was reasonable and manageable</td>
<td>3.83</td>
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<tr>
<td><strong>Thinking about the system overall and its output</strong></td>
<td></td>
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<tr>
<td>I feel suspicious of the DAISY system</td>
<td>2</td>
</tr>
<tr>
<td>I am confident in the DAISY system</td>
<td>3.25</td>
</tr>
<tr>
<td>The DAISY system has high integrity</td>
<td>3.5</td>
</tr>
<tr>
<td>I can trust the DAISY system</td>
<td>3.42</td>
</tr>
<tr>
<td>The DAISY system provides security</td>
<td>3.8</td>
</tr>
<tr>
<td>The DAISY system is reliable</td>
<td>3</td>
</tr>
</tbody>
</table>
Next Steps

• Feasibility clinical trial at Scarborough Hospital
• Setup of recently acquired ARI robot\(^1\)
• Hybrid-AI extension
  • Bayesian reasoning for domain knowledge
  • Machine learning for non-verbal cues
    • cough, jaundice, etc.

\(^1\)PAL Robotics - ARI social robot
https://pal-robotics.com/robots/ari/
DAISY in the media

University of York: Institute to research benefits of AI

By Rachel Russell

The University of York has set up a living lab to reassure people about Artificial Intelligence (AI)

Minister visits Institute for Safe Autonomy to understand AI and robotics in public services

Posted on 11 July 2023

The Secretary of State for Science, Innovation and Technology visited the University of York’s Institute for Safe Autonomy to see the latest technological advancements in the development of AI and robotics.

Dr Ioannis Stefanakos of the University of York has his blood pressure checked by DAISY, an AI-equipped robot designed to provide triage and assistance in A&E

Publications


Visit our DAISY demo at the Showcase – booth 16