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Hey Inspecta! An AI-Enabled Smart Assistant for International Nuclear Safeguards Inspectors

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An AI-enabled smart digital assistant may increase efficiency and effectiveness of international nuclear safeguards (INS) inspections

INS inspections are challenging

- Difficult/hazardous environments
- Personal Protective Equipment (PPE)
- Non-native languages
- Physically and mentally challenging
- Limited time for activities
- Tedious
- Jetlag!

https://www.iaea.org/newscenter/multimedia/photoessays/moments-time

Our current world is filled with:

Can we use AI/smart assistants for INS inspections?

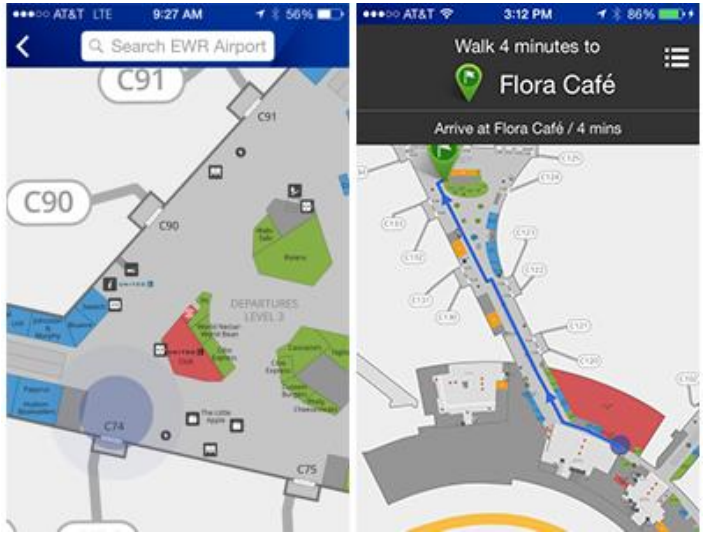
Likely! But what tasks would have most impact on effectiveness and efficiency? What would be allowed? Note that this should work WITH human, not replace them.

What is Inspecta?

- Inspecta – International Nuclear Safeguards Personal Examination and Containment Tracking Assistant
  - An artificial intelligence (AI)-enabled Smart Digital Assistant (SDA) prototype for safeguards inspectors
  - Similar in function to Alexa or Siri
  - Aid with note-taking, location, timers, etc.
  - Provides support for safeguards-specific tasks, for example using optical character recognition to read seal numbers
  - Multiple methods of interaction – utilize speech synthesis & Natural Language Processing (NLP) to communicate with inspector verbally
    - Application running on small portable device
- An FY21 NA-22 funded scoping study defined what an AI-enabled smart digital assistant for international nuclear safeguards is and what high-impact tasks it may perform
  - Performed review of IAEA publications and conducted interviews with 8 subject matter experts and former IAEA inspectors
  - Interviews resulted in 5 most common tedious, challenging, prone to error tasks and we selected seal examination from that list
- In FY22, we've begun development of a prototype after selecting seal examination task, determining what technical skills are needed for the task and determining a prototype platform

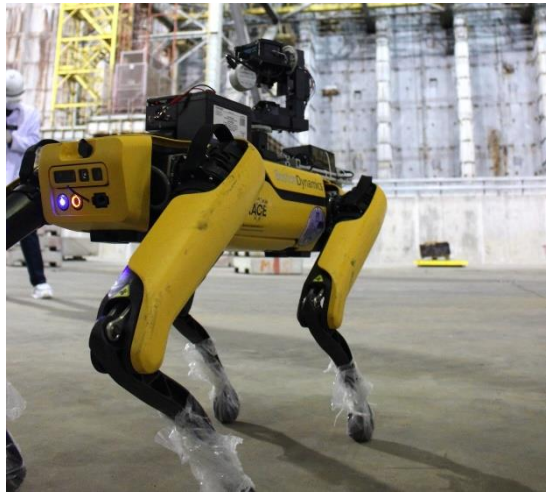
Technical capabilities to support Inspecta “skills” include:

Indoor navigation

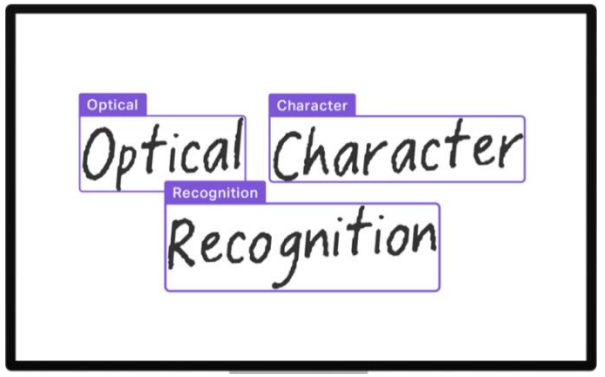


https://www.futuretravelexperience.com/2015/08/united-adds-indoor-maps-and-beacon-based-wayfinding-to-app/

Robotics



https://spectrum.ieee.org/automaton/robotics/robotics-hardware/boston-dynamics-spot-Chernobyl



https://www.elementai.com/api/ocr

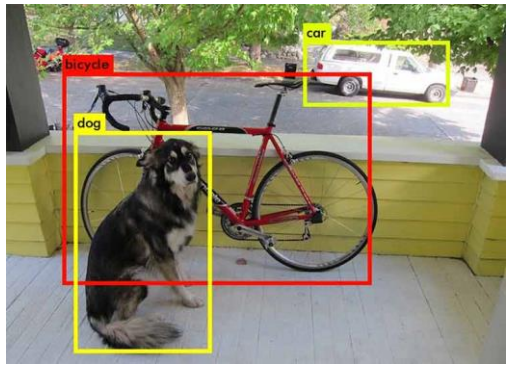
Information recall, speech synthesis, voice-to-text

https://www.amazon.science/blog/how-alexa-is-learning-to-converse-more-naturally

Anomaly detection

https://thedatascientist.com/anomaly-detection-why-you-need-it/

Object identification



https://www.techleer.com/articles/123-google-to-help-developers-in-object-identification-using-tensorflow-object-detection-api/

Examining and verifying seals, currently

1) Inspector(s) escorted to location with seals by host
2) Inspector finds first seal to examine, finds the seal number on their paper list, and adds a check mark after physical inspection of seal and wire for signs of tamper
   - There are usually no maps or additional information provided, just location names. Exception is large facilities such as GCEPs.
   - Inspector also examines containment that seal is attached to
   - To test attachment of seal, inspector:
     - Holds wire near base of seal firmly in one hand and attempts to pull away cover of seal, and
     - Holds base of seal firmly in one hand and attempts to pull seal away from item it is attached to.
3) A subset of seals will be removed to be verified at HQ – inspector should use a random number generator and a formula to determine how many seals to remove and which ones.
4) In practice, this is often performed by a single inspector as other inspectors are performing other tasks.

Image: IAEA, 2020

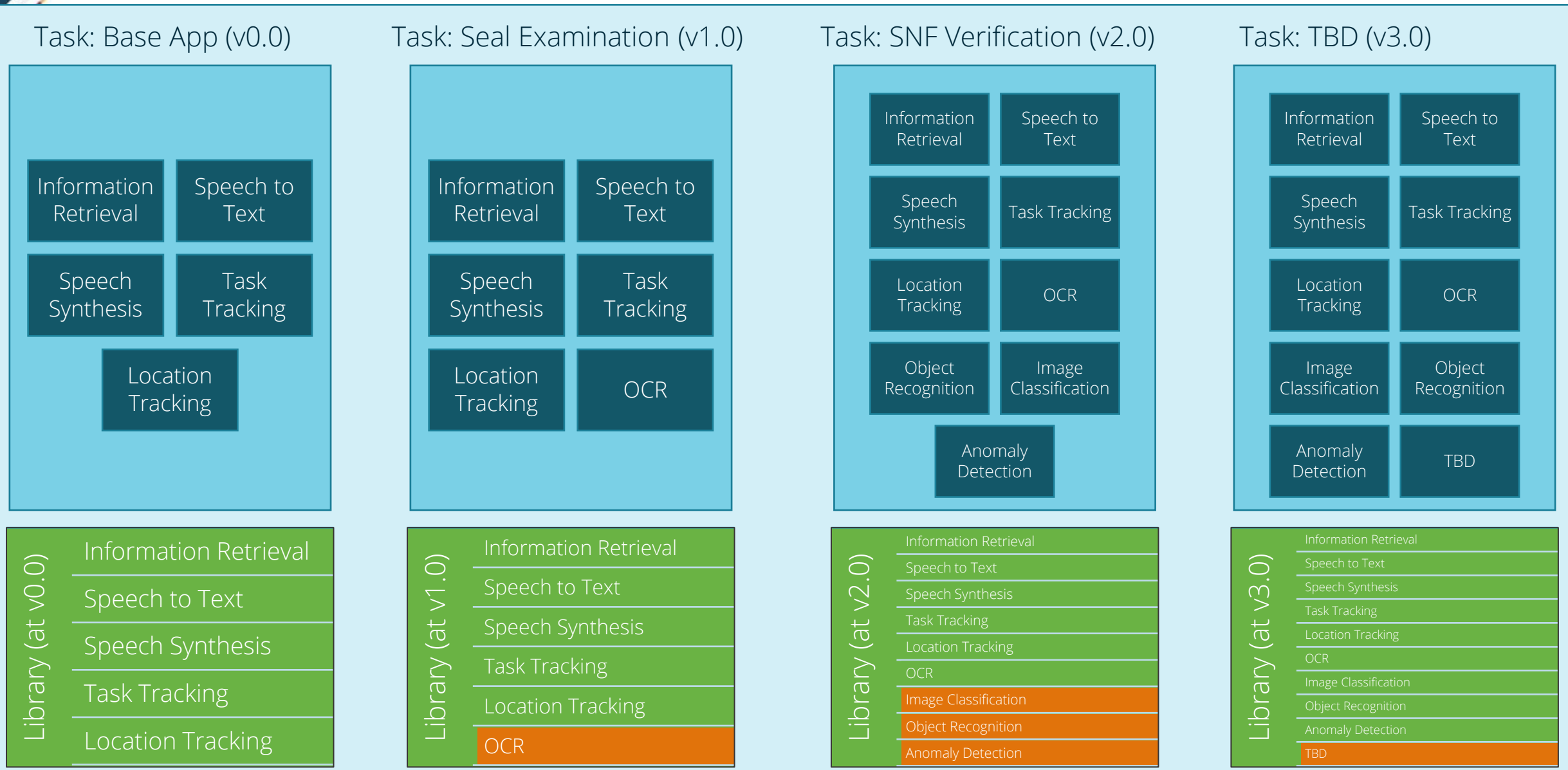
Seal checking example with Inspecta assistance

Inspector "says", or takes following [action]	Inspecta "says", or takes following [action]
[At HQ, inspector prepares Inspecta for trip by providing seal list (file transfer or OCR, TBD), facility agenda (to be added to Inspecta later), any maps if available]	[Inspecta downloads or uses OCR to obtain seal list. Inspecta downloads general area map and will likely generate a map in real-time during inspection]
[At facility, inspector is escorted by host to seal area and goes to first seal] "Inspecta, open seal checking skill at Atlantis Reactor"	"Ok, opening seal checking skill and seal list for Atlantis Reactor. I have used my random number generator and statistics formula to calculate how many and which seals to remove for full HQ verification."
[Inspector allows Inspecta to view seal ID by moving camera]	[Inspecta uses OCR to capture seal ID and marks off list. Inspecta notes location if possible, or begins learning location.] "Confirming seal 123"
[Inspector physically checks seal and wire for proper attachment and tamper, moves to next seals]	
[Inspector moves to next seal and allows Inspecta to view seal ID]	"Confirming seal 456. This seal has been chosen for removal and verification. Please remove seal and apply new seal."
[Inspector removes seal 456, finds a new seal, attaches it and informs Inspecta of newly added seal number] "Adding seal 100 to inventory to replace seal 456"	"Confirming seal 100 has replaced seal 456" [Inspecta confirms using OCR as well]

Why not Siri, Alexa or Mycroft?

- Cloud-based
  - Requires connection to Siri/Alexa servers to work properly
  - Connectivity would likely be unavailable in a nuclear facility (either due to dead-spots or security concerns)
- Proprietary
  - Limited/no access to source code
  - Significant security concern to IAEA/facility operators
- Data privacy questionable
  - Because data would be sent/received from Siri/Alexa servers, there may be a challenge in ensuring data security
- Mycroft is open-source digital assistant platform but skills and support are limited

Modular architecture enables Inspecta to adapt to future needs



Conclusion and next steps

- Integrating AI/smart assistants with INS inspection workflows has the potential to increase efficiency and effectiveness (let human inspectors do what they do best, and AI/robotics do what they do best)
- Development team working on development infrastructure (i.e. repositories, CI/CD pipelines, hardware and software acquisitions), machine learning skills development (identify which algorithms will be used/adapted), app wireframe
  - TRL 3 – 4
- Safeguards team working to define task in detail, user interface with Inspecta, sub-tasks that demonstrate feasibility
- Inspecta 1.0 prototype expected December 2022
- Related project NA-22 funded “Trust in Auditory User Interface” will help guide specific user interface experience

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