Using Natural Language to Enhance Mission Effectiveness

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Outline

- Introduction and background
- Acceptance of using voice
- Intent inference

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Introduction & Background

- Current interaction with a drone requires the operator to understand the specifics of the controller and the drone's dynamic behavior
- Not a natural and higher level teaming relationship
  - Increased workload
  - Decreased situation awareness
  - Decreased trust
- Natural language may increase collaborative teaming

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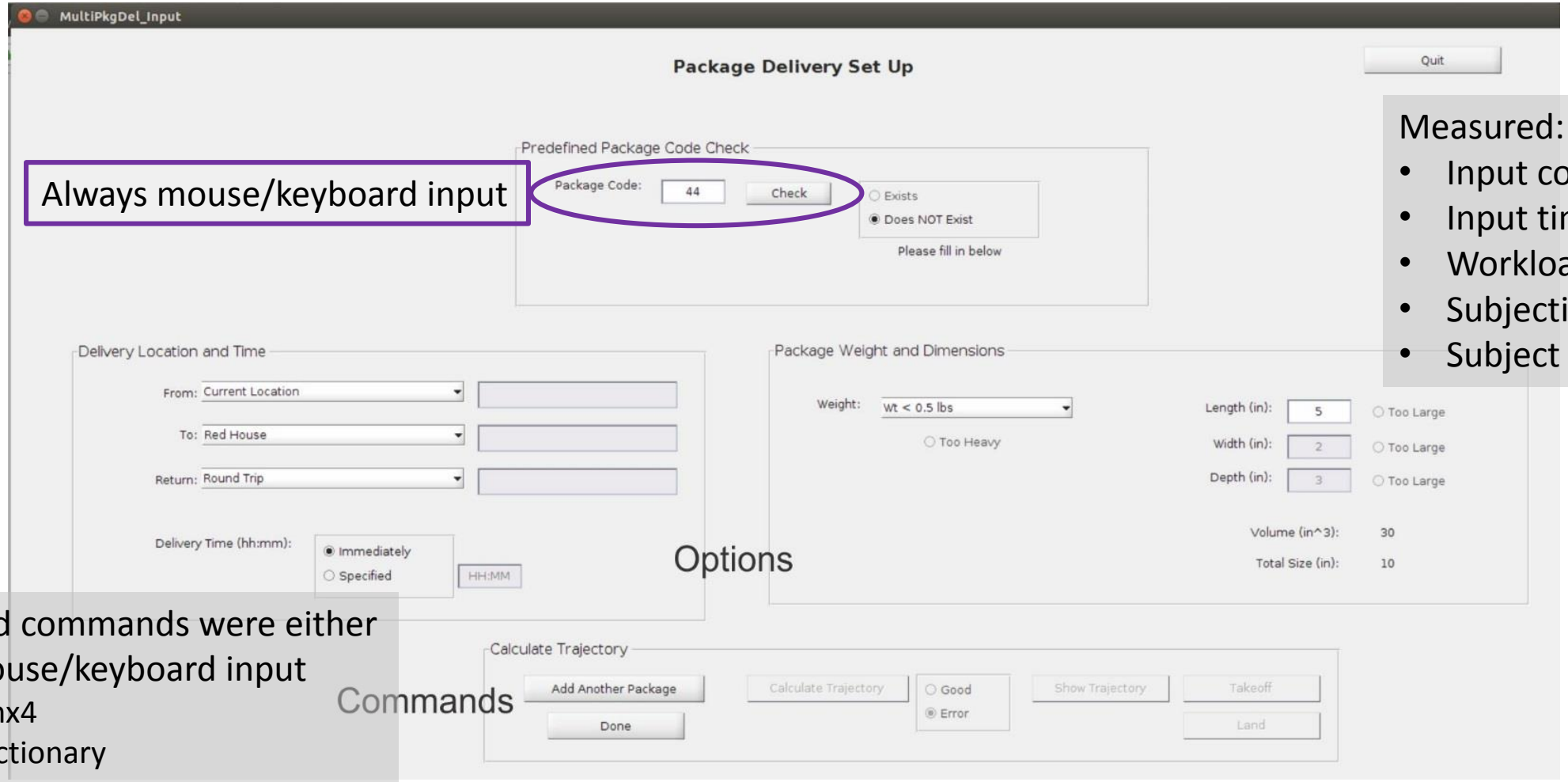
Initial Voice Usability Experiment



Measured:

- Input correctness
- Input time
- Workload ratings
- Subjective ratings
- Subject comments

Options and commands were either voice or mouse/keyboard input

- CMU Sphinx4
- Defined dictionary

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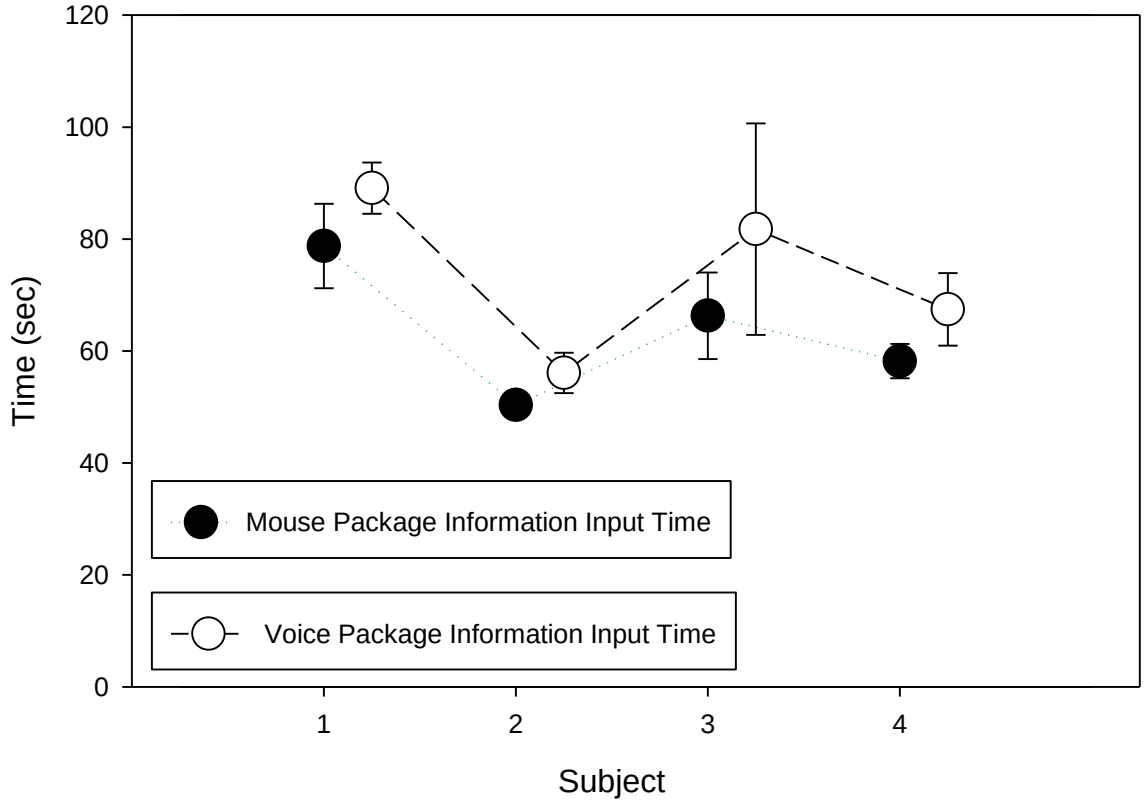
Options Input Times

- *Option* voice input took slightly more time



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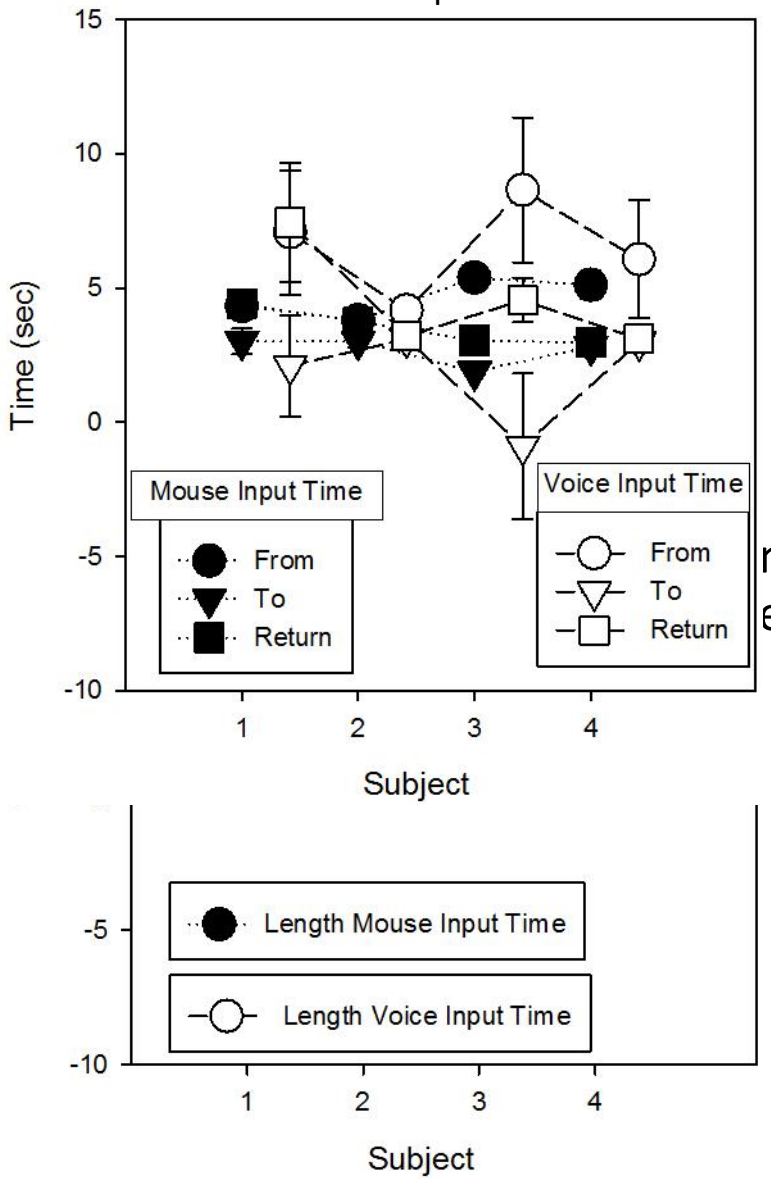
Menu Option Input Time

"Round Trip"



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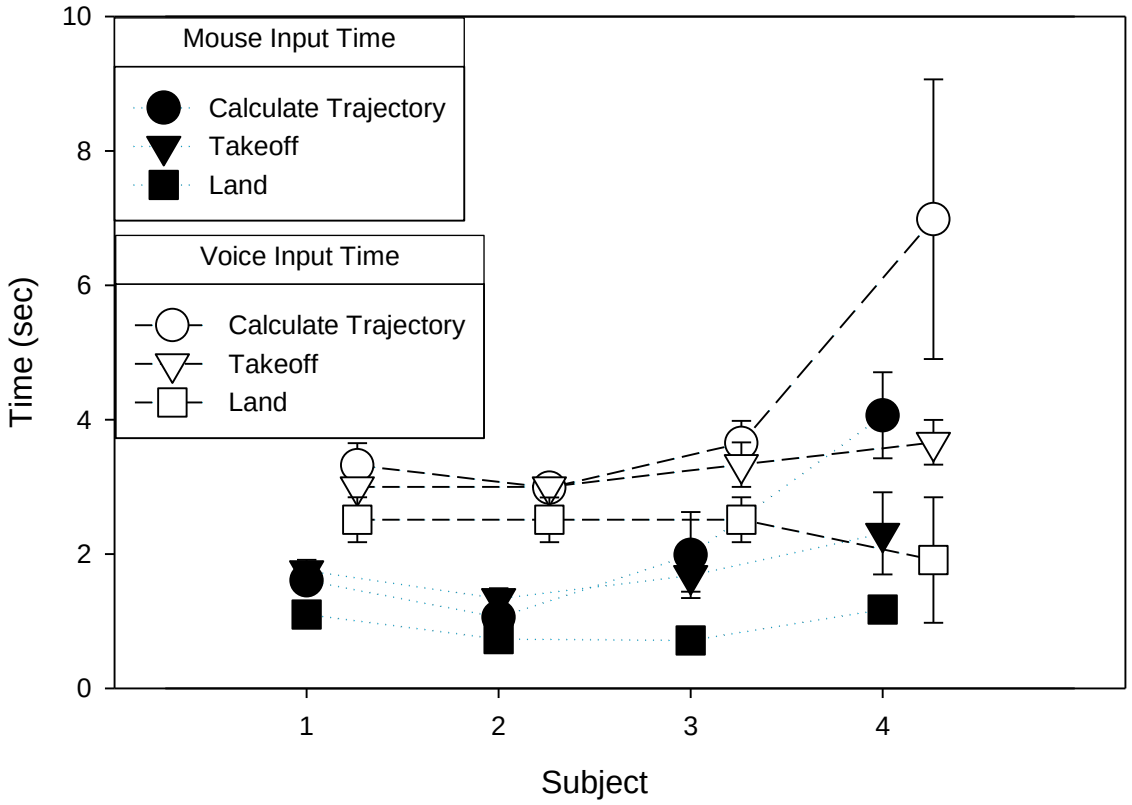
Commands Input Times

- *Command* voice input took longer than mouse input
  - Longer phrases took more time
- Use mouse or touch input for mission critical or safety related commands



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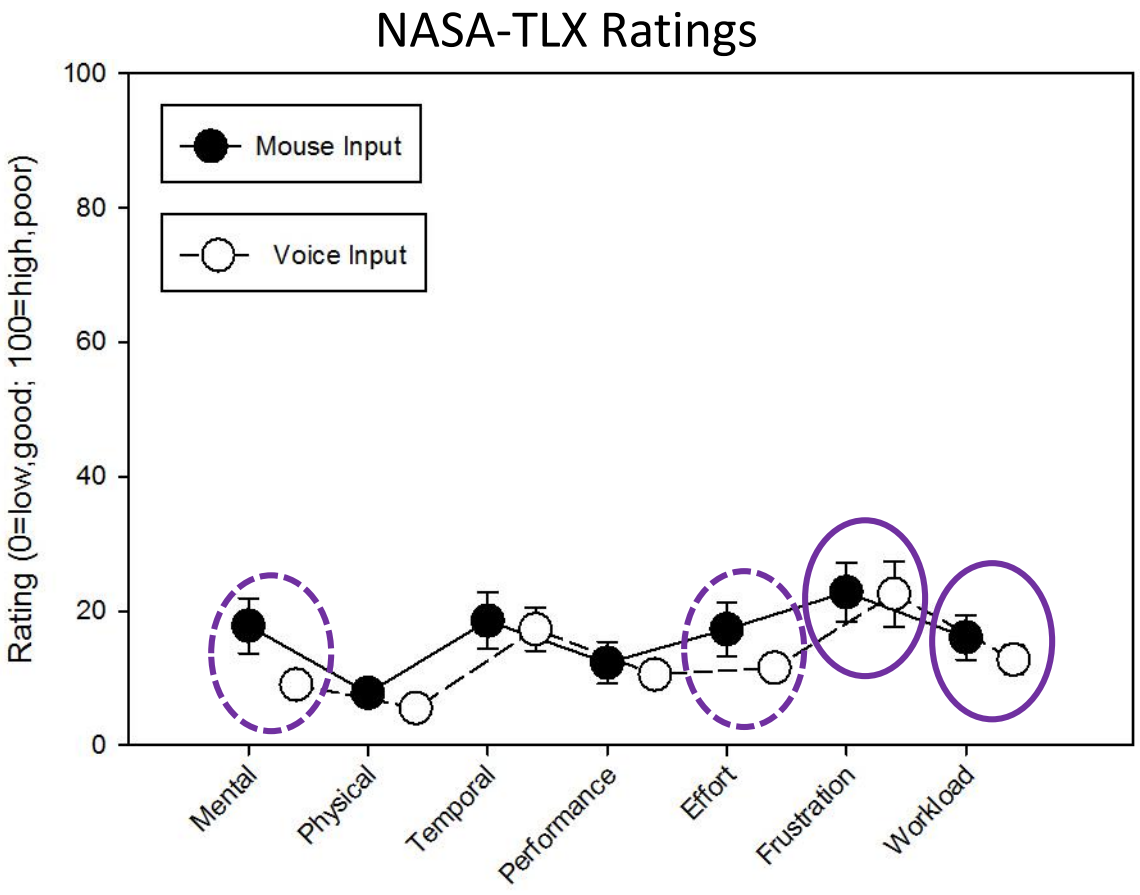
Workload



- Voice input lower overall workload

  Especially for:
  - Mental
  - Effort

- Frustration about equal
  - Time for voice command to register
  - No indication on screen until something changed that system was parsing voice command
    - Lacking intent information

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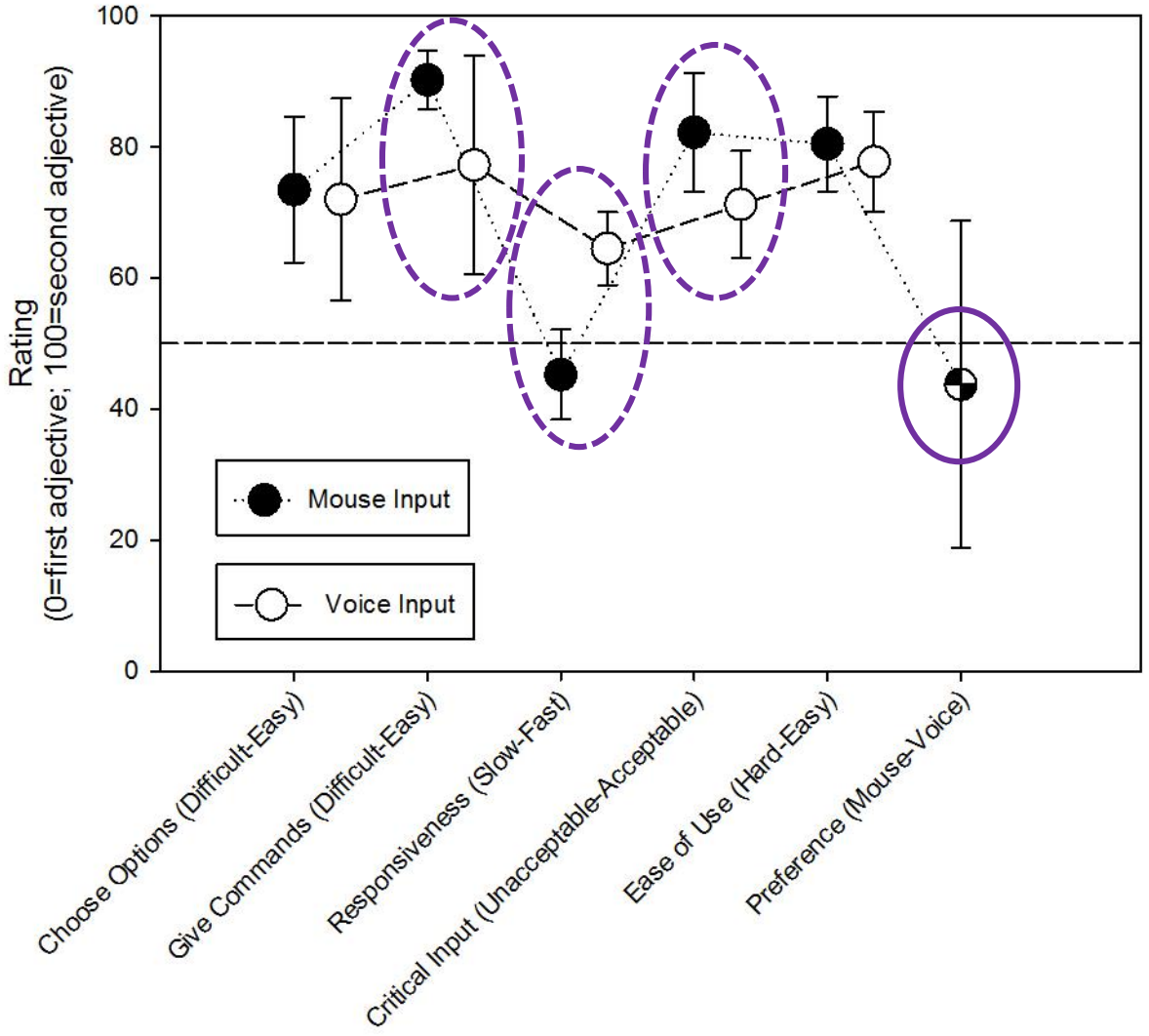
Subjective Ratings and Comments



- Slight overall preference for mouse input
  - Except for Responsiveness
    - "Tedious to move the mouse around"
- Largest differences are for *Commands*
  - Use mouse or touch input for mission critical or safety related commands

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Initial Voice Usability Experiment Summary

- Voice took longer to input information
  - Longer phrases took longer
- Voice has slightly lower workload
  - Frustration about equal with mouse input → No indication that voice system was working
- Subjective preferences indicated mouse input preference
  - Critical input commands had lowest preference in using voice input

- Voice input acceptable to non-critical input
- Mouse/keyboard/touchscreen preferred for critical input

Inferring *Commander's Intent* by machine may further increase teaming

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Predicting Commander's Intent

- Most users (of computers, autonomous systems, and technology in general) verbalize while working with machines
  - Especially true for members of teams with multiple humans
- Often verbalizations take the form of imprecise questions
  - "What's it doing now?"
- Can we predict the *Commander's Intent* and provide desired information on UAV behavior based only on such simple verbal questions?

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Latent Semantic Analysis (LSA)

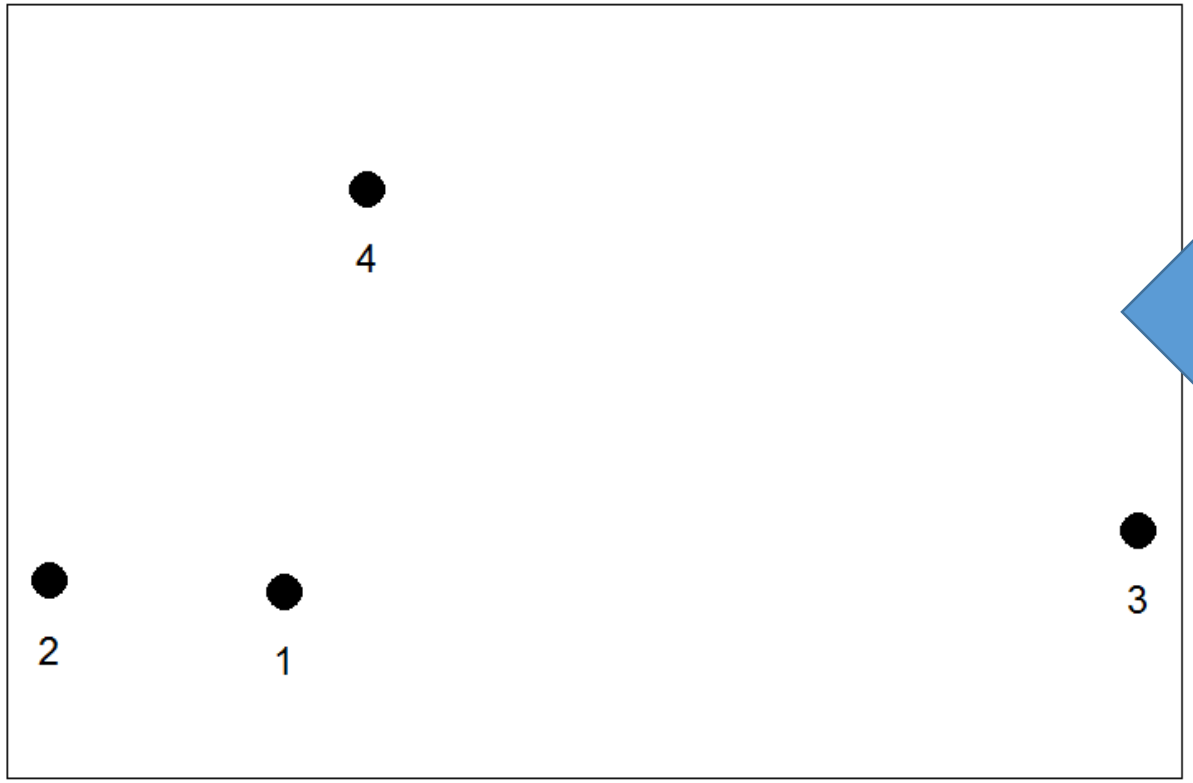
- Well-established tool in computational linguistics
- Determines the degree of semantic relationship between two pieces of language (documents, verbal utterances, etc.)

Methodology:

- Create term-document matrix of all words and utterances in the corpus
- Decompose using singular value decomposition to produce a similarity matrix
- Use multidimensional scaling to plot these similarity values graphically
- The closer two documents are, the more closely semantically they are related

LSA Example

Utterance 1: “One fish two fish red fish blue fish”
Utterance 2: “Black fish blue fish old fish new fish”
Utterance 3: “This one has a little star this one has a little car”
Utterance 4: “Say! What a lot of fish there are”

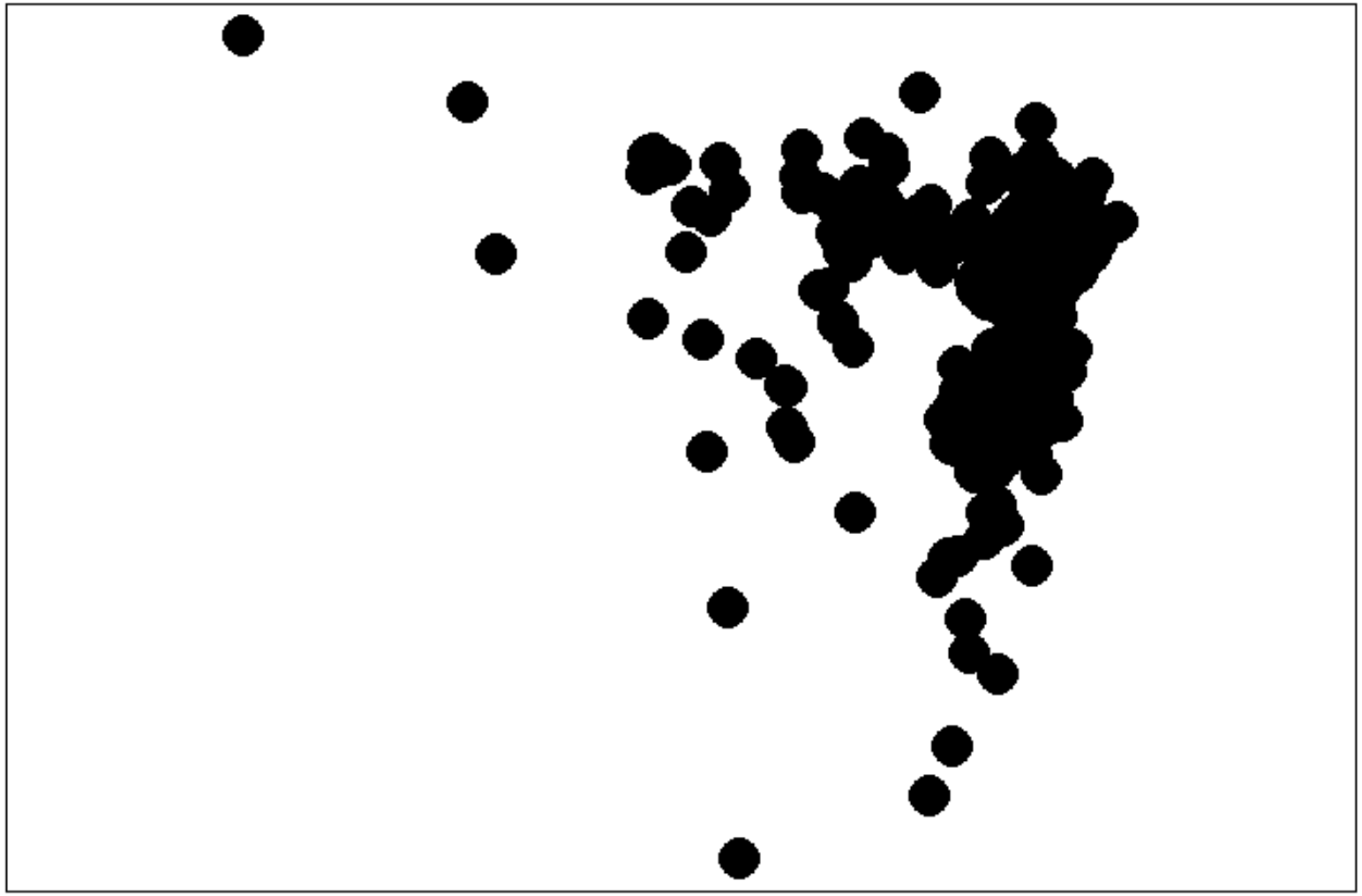


	U1	U2	U3	U4
one	1	0	0	0
fish	4	4	0	1
two	1	0	0	0
red	1	0	0	0
blue	1	1	0	0
black	0	1	0	0
old	0	1	0	0
new	0	1	0	0
this	0	0	2	0
one	0	0	2	0
has	0	0	2	0
a	0	0	2	1
little	0	0	2	0
star	0	0	1	0
car	0	0	1	0
say	0	0	0	1
what	0	0	0	1
lot	0	0	0	1
of	0	0	0	1
there	0	0	0	1
are	0	0	0	1

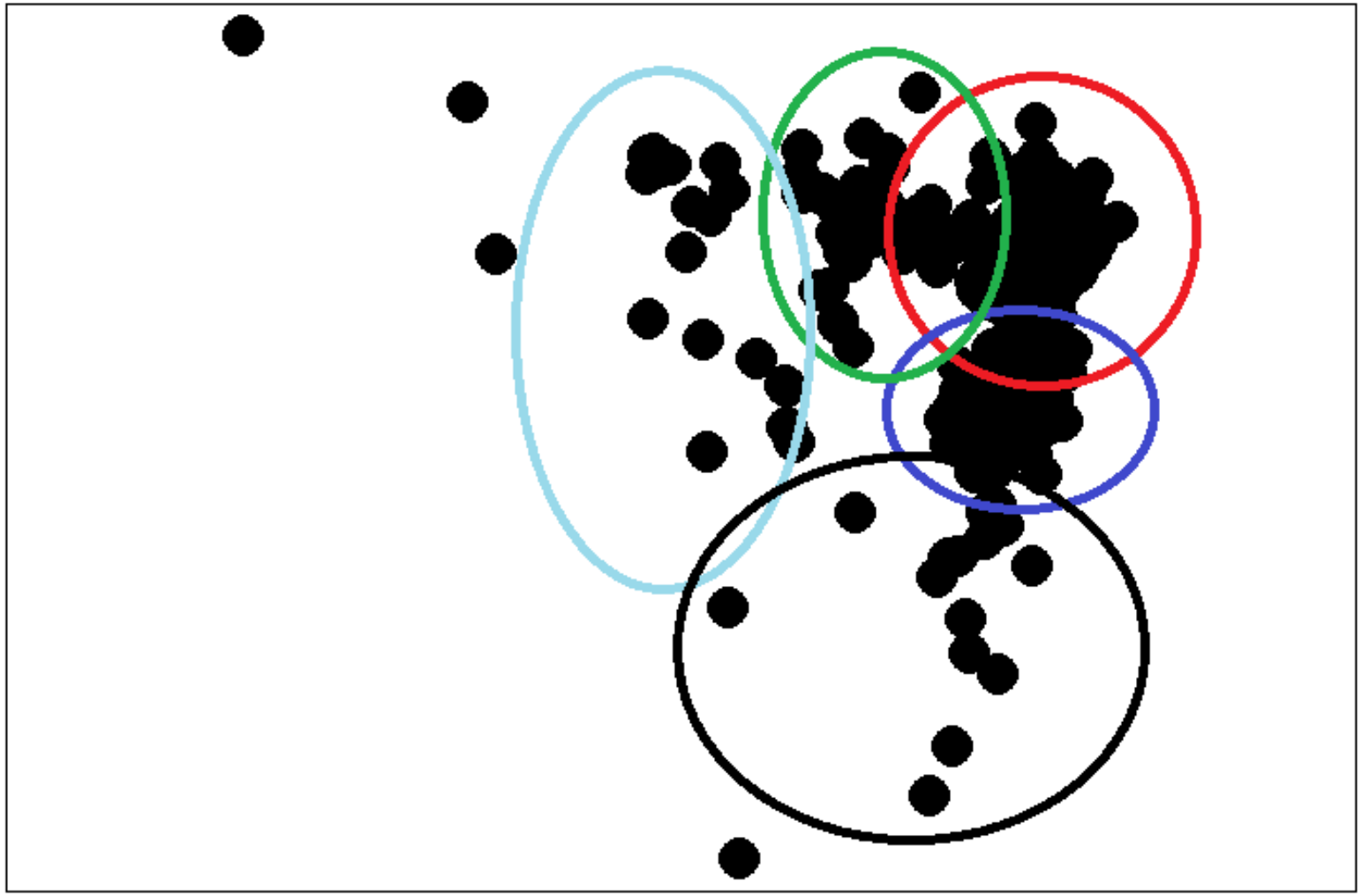
Generating the Semantic Map

- Observed language used by human operators while working with UAVs at NASA Langley's Autonomy Incubator
- Analyzed data to produce a semantic map for UAV operation
  - A predefined semantic space enables better predictions
  - Semantic map can be continually trained
- LSA carried out in R Statistical Programming Language

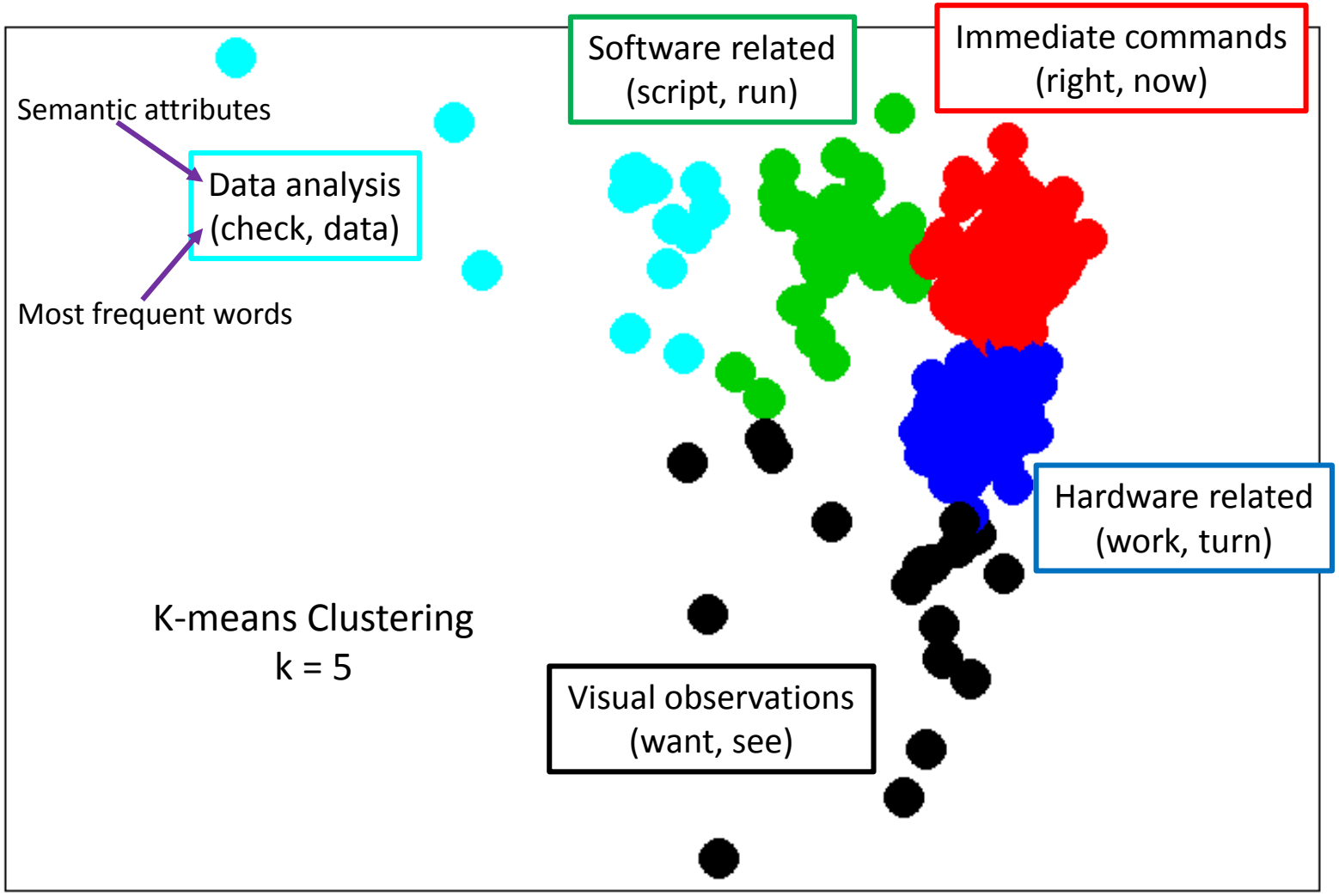
Semantic Map of the Autonomy Incubator



Semantic Map of the Autonomy Incubator



Semantic Map of the Autonomy Incubator



- Clusters on semantic map defined by different language
- New documents/utterances can be mapped to an existing semantic map
  - Semantic context of new utterance can be predicted based on which cluster is closest to newly mapped utterance
- Ability to predict semantic area of an utterance can be applied to prediction of the content area of questions
  - "What's it doing now?"
- LSA allows for prediction of *Commander's Intent* for UAV operation

Predicting Commander's Intent – Planned Research

1. User's verbal interactions with UAV transcribed using CMU Sphinx4
2. System triggered when the user asks a question
3. Question and immediate verbal context mapped to existing semantic map
4. Determine closest cluster to the newly mapped information
   - Information associated with this closest cluster provided to user
5. Correctly interpreted utterances added to existing semantic map to further define semantic sphere

- Autonomous agent able to answer back appropriately to the question *"What are you doing"*

  Based on:
  - Mission context
  - Previous utterances