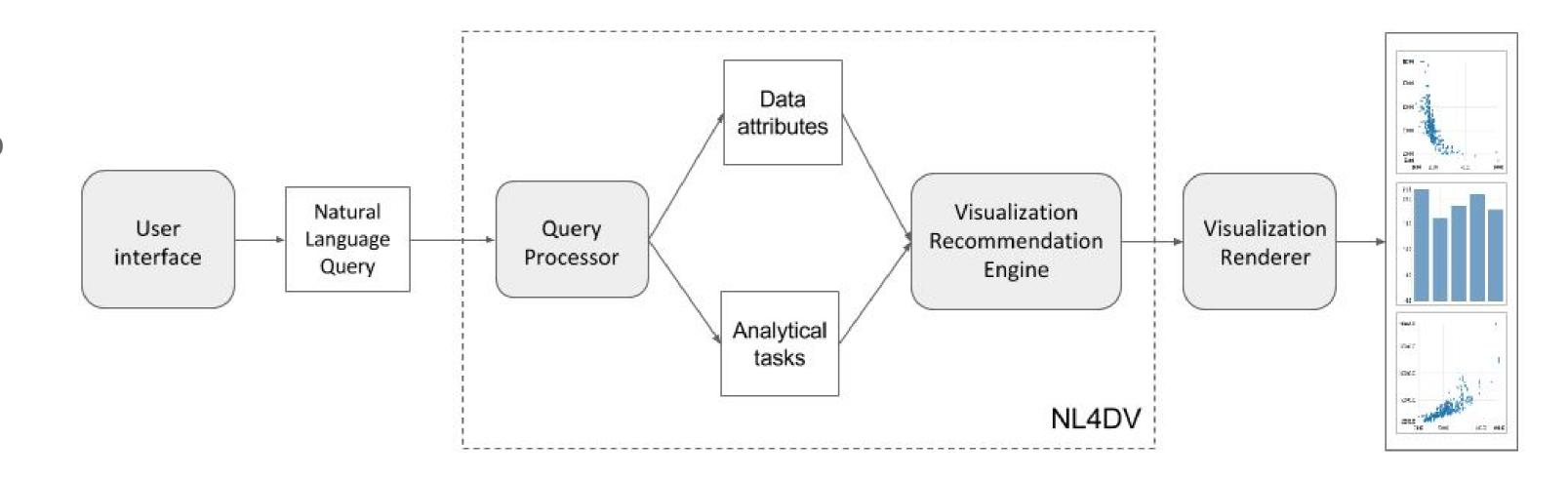
NL4DV: Toolkit for Natural Language Driven Data Visualization

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Developing natural language interfaces for visualization systems is a challenging task and requires system developers to spend time and effort on implementing Natural Language Processing (NLP) components necessary to convert natural language queries into visualizations.

NL4DV provides high-level functions developers can use to create natural language-driven data visualization systems. In addition to extracting data attributes and analytical tasks from a query, NL4DV also suggests a ranked list of visualizations that are most relevant to a given query.



Data Processor AttributeAliasMap Attribute dataAttributesMap Extractor taskList "Are wider cars Visualization Query Response recommendedVisualizations Recommender Processor Processor expensive?" Task Identifier (Query Analyzer) TaskKeywordMap *NL4DV*

Components:

- DataProcessor. Processes the input data source to extract details about individual attributes (data type, domain, related attributes, etc.)
- QueryProcessor. Processes the input query to generate POS-tags and n-grams.
- AttributeExtractor. Identifies the attributes mentioned in the query and maps these attributes to the identifying substrings in the query.
- Taskldentifier. Identifies analytical tasks a user is trying to perform using a query.
- VisualizationRecommender. Uses the data attributes and tasks identified to generate a ranked list of relevant visualizations for the input query.
- ResponseProcessor. Merges the output from the other modules to generate the response object.

NL4DV is currently being used by graduate students. Students have used the toolkit to build natural language driven visualization systems from scratch. Additionally, some students have used the toolkit to add an optional natural language query interface to existing systems.

Ongoing work includes. . .

- Experiments to evaluate the toolkit's performance based on its responses.
- Using advanced dependency parsing techniques to better map tasks to attributes in a given query.
- Using Artificial Intelligence Markup Language (AIML) to integrate a conversational agent into the toolkit.

<u>Usage</u> "Retail Price" : ["expensive"] Step 1: Import NL4DV. ealer Cost" : ["expensive"] "Width" : ["wider"] import nl4dv Attribute Step 2: Initialize data source. Extractor nl4dv.data(dataFile) Visualization Step 3: Pass the query as a Query "Are wider cars more expensive?" Recommender processor string. Task nl4dv.analyzeQuery(query) [(are), (wider), (cars), . . . (wider Identifier cars),... (wider cars more "taskRelevanceScore": 1.0, expensive)] "visType":"scatterplot" "visAttributes": { All responses are in the form [('are', 'NNP'), ('wider', 'JJ'), ('cars', "xAxis":"Retail Price" "confidence": 1.0. of structured JSON objects. 'NNS'), ('more', 'RBR'), "yAxis":"Width" "mappedObjects": These can be parsed easily to ('expensive', 'JJ')] {"attribute": "Width"} {"attribute": "Retail Price"} update the user interface or {"attribute": "Dealer Cost"} render visualizations. "task": "Correlate"

Process

more expensive

Sample applications built using NL4DV

Are cars with higher MPG more expensive?

180,000 -

140,000 -

120,000 -

Are cars with higher MPG

City Miles Per Gallon

Data Summary

City Miles Per Gallon: 10-60

Dealer Cost: 18451-16375

Horsepower(HP): 73-493

Retail Price: 16385-22515

Weight: 3585-3583

Width: 64-81

Wheel Base: 129-124

Len: 143-221

RWD: 0-1

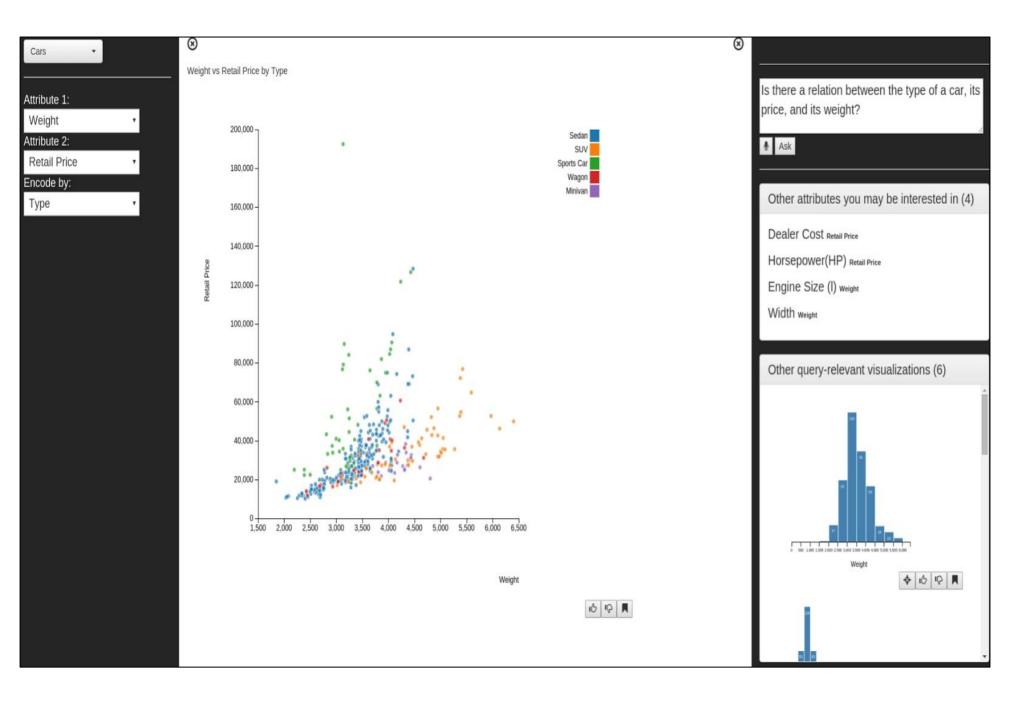
Highway Miles Per Gallon: 12-66

Armada SE, Mercedes-Benz C240, BMW X5

Type: Sedan, SUV, Sports Car, Wagon,...

Engine Size (I): 1.5-4.5

AWD: 0-1



SermoViz

SpeechVis SpeechVis uses NL4DV to present a dataset summary and lets users generate visualizations using natural language. Similar to DataTone by Gao et al, it also highlights ambiguity in a question with the help of dropdowns.

ListView List Modes Any All Same All-Any Add new List TT↓ TT↑ I I I ■ | ↑ | 1½ 1₹ <u>=</u> | ↑ II IF ■ | ↑ | 12 17 = | 1 1 1 1 Q E = = Q 1 1 1 Q 1 1 1 Q 1 1 1 Q Daniel A. Spielman Cornell University - USA University of Oxford - United Warsaw University - Poland Tsinghua University - Beijing University of Minnesota - Tw New York University - USA University of Michigan - USA California Institute of Technological Johns Hopkins University - USA University of Memphis - USA Saint Petersburg State Univers. Royal Institute of Technology University of Minnesota - Twin Carnegie Institute of Technological University of Massachusetts Merrimack College - USA University of Edinburgh - Unite University of Florida - USA University of Utah - USA McGill University - Montreal

ListView

ListView is using NL4DV to test whether providing an optional natural language query interface can help users in performing tasks faster and more easily compared to the existing graphical user interface.

SermoViz is an exploratory data analysis tool which allows users to ask questions to explore a dataset. It uses NL4DV to process the questions, suggest potentially interesting attributes, and select and order visualizations.



NL4DV will soon be available as open-source software for developers to use for building and experimenting with natural language interfaces for visualization.