smartTalk: A Learning-based Framework for Natural Human-Robot Dialog

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Abstract

We present a learning-based framework called smartTalk for natural-language human-robot interaction. smartTalk is an *intent-based* framework that classifies a user-given command to an action. Through extended use and interaction, smartTalk is able to learn new commands, as well as adapt to the user's behaviors and habits.

Motivation

Effective interaction between humans and robots in any environment relies on a natural exchange of information. It is not only necessary for robots to be able to respond during interaction, but also have the ability to learn new instructions, and extend their vocabulary.

Fig 1: A Husky AGV Robot during a field trial.

Approach

The classification model can be pre-trained by the user, or generated 'on the fly', given existing robot functionality. smartTalk maps a given command to an action executed by the robot.

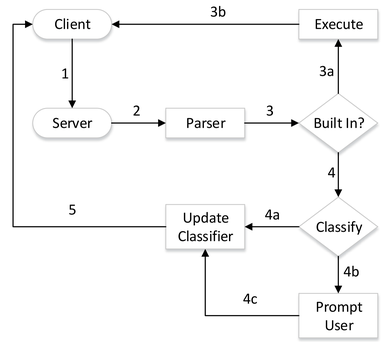


Fig 2: System flow diagram of the smartTalk Framework

- Client-server model with smartTalk as a backend
- Perform speech to text, though smartTalk is modality agnostic
- Classify new commands against a learned model of instructions
- Mapping a command's classified *intent* to a function performed by the robot
- Expand knowledge base through interaction

Command Classification

smartTalk uses a Naïve Bayes classifier to determine the user's *intent* of a given command. The model computes the confidence of each class to determine the uncertainty of a command. Commands that fall below an uncertainty threshold are not executed, and the user is prompted for the correct classification to update the model. Commands that pass the threshold are executed, and used to update the model.

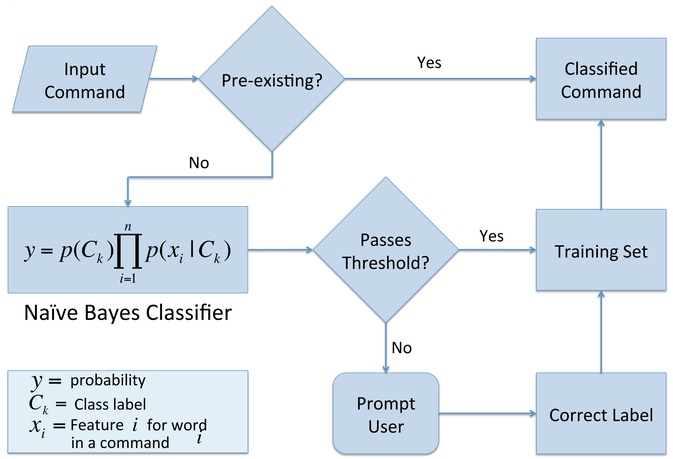


Fig 3: System flow diagram of smartTalk's Classification system

User Feedback

The three types of feedback given to the user are:

- *Acknowledgement*
- *Risk Assessment*
- *Uncertainty*

Acknowledgement provides the user with the knowledge that a command's intent was successfully understood, so the user can direct their focus on a separate task.

Risk Assessment provides a safe and successful interaction[2]. If the risk calculated passes a threshold, then the user will be prompted with a confirmation before a command is executed.

Uncertainty allows the robot to expand its knowledge base by prompting the user for additional information when a command is unsuccessfully classified. Given this information, smartTalk will update its model.

Experiments

We tested our classification model in several simulated environments. Figures 1 and 2 show the confusion matrices, and Tables 1 to 4 show training and testing data for two environments.

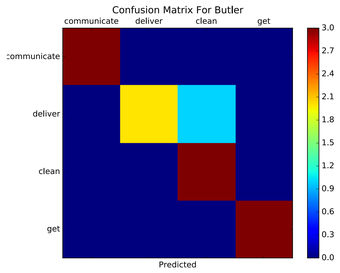


Fig 3: Confusion matrix for a Service Robot

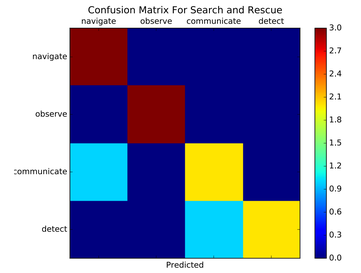


Fig 4: Confusion matrix for a Search and Recue Robot

Service Robot Training Data	
Command	**Label**
bring my plates to the kitchen and put them on the counter	deliver
put my clothes in the hamper	deliver
put my mug into the dishwasher please	deliver
bring my trash outside and put it in the barrel	deliver
throw my shoes in the closet	deliver
take this glass to the kitchen	deliver
get me my shoes from the closet	deliver
bring me the remote	get
go grab my clothes from the dryer	get
can you go get the mail please	get
can you go to the cellar and get me a bottle of soda	get
hurry up and get me my keys, we're late	get
clean up this mess	clean
sweep up the kitchen	clean
pick up all of my clothes off of the ground and put them away	clean
get the vacuum out of the closet and vacuum the hallway	clean
can you pick up all this junk on the ground	clean
get the paper towels and wipe up the juice on the ground	clean
do I have anything on my calendar for today	communicate
how much battery do you have left	communicate
hey robot where are you right now	communicate
what time is it	communicate
do you know where I left my car keys	communicate
what is the temperature in here	communicate

Table 1

Search and Rescue Robot Training Data	
Command	**Label**
start recording and send me the video stream	observe
take a picture	observe
can you zoom in some more and take a picture	observe
okay start recording	observe
if you find a survivor send back a picture	observe
start taking pictures every minute	observe
fly back to base	navigate
follow me	navigate
okay follow us	navigate
go over to that pile of rubble	navigate
go up that hill and let me know what you see	navigate
go to the base and get the rest of our team	navigate
head over to group A and report your findings	navigate
look for any survivors in the area	detect
try and see if you can find any signs of activity	detect
fly overhead and try to find where the fire is	detect
follow this path and try to find footprints	detect
fly back to base, but also look for any signs of movement	detect
call for reinforcements to your area	communicate
hey robot where are you right now	communicate
hey have you found anything	communicate
what can you see	communicate
how much battery do you have left	communicate

Table 3

Service Robot Testing Data	
Command	**Label**
take my plate and glass back to the kitchen please	deliver
put this shirt on my bed please	deliver
can you put all of the dishes into the dishwasher	deliver
get my car keys from the drawer	get
go to the fridge and grab me a beer please	get
go get me another pair of socks from my dresser	get
sweep up all of these crumbs on the floor	clean
can you vacuum all of the bedrooms	clean
pick all of this garbage off of the ground	clean
did I plan anything for today	communicate
what's the time	communicate
do you know where I put my wallet	communicate

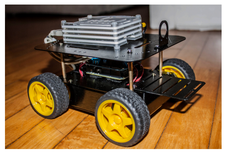
Table 2

Search and Rescue Robot Testing Data	
Command	**Label**
hey take a picture	observe
start taking a video	observe
every thirty seconds take a photo	observe
alright fly back to base	navigate
follow that group up there	navigate
fly up overhead and follow us	navigate
look over there and try to find any survivors	detect
try and locate the fire	detect
can you see any people down there	detect
how much battery is left	communicate
what's your location	communicate
do you have any information updates	communicate

Table 4

Robot Trials

A qualitative experiment was performed on a custom built indoor robot for simple navigation tasks.



Conclusion

smartTalk presents a method for natural-language human-robot interaction. Future work looks at creating a more accurate model of the user and risk during task execution.

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[1]: "TextBlob: Simplified Text Processing" https://textblob.readthedocs.org
[2]: J. Sattar and J. J. Little, "Ensuring safety in human-robot dialog — A cost-directed approach," *2014 IEEE International Conference on Robotics and Automation (ICRA)*, Hong Kong, 2014, pp. 6660-6666.