From Bot to Bot: Using a Chat Bot to Synthesize Robot Motion

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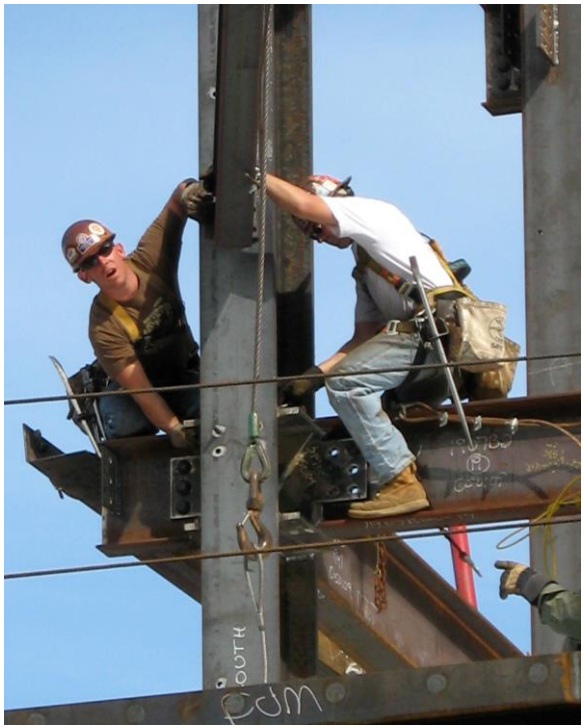
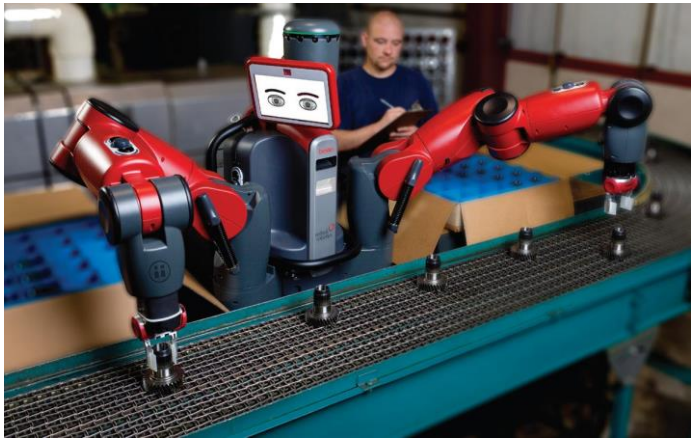
Human collaboration : fluid. multi-modal, responsive



Human & Robots : A pre-programmed saga



Robots operate in very well defined (limited) scenarios

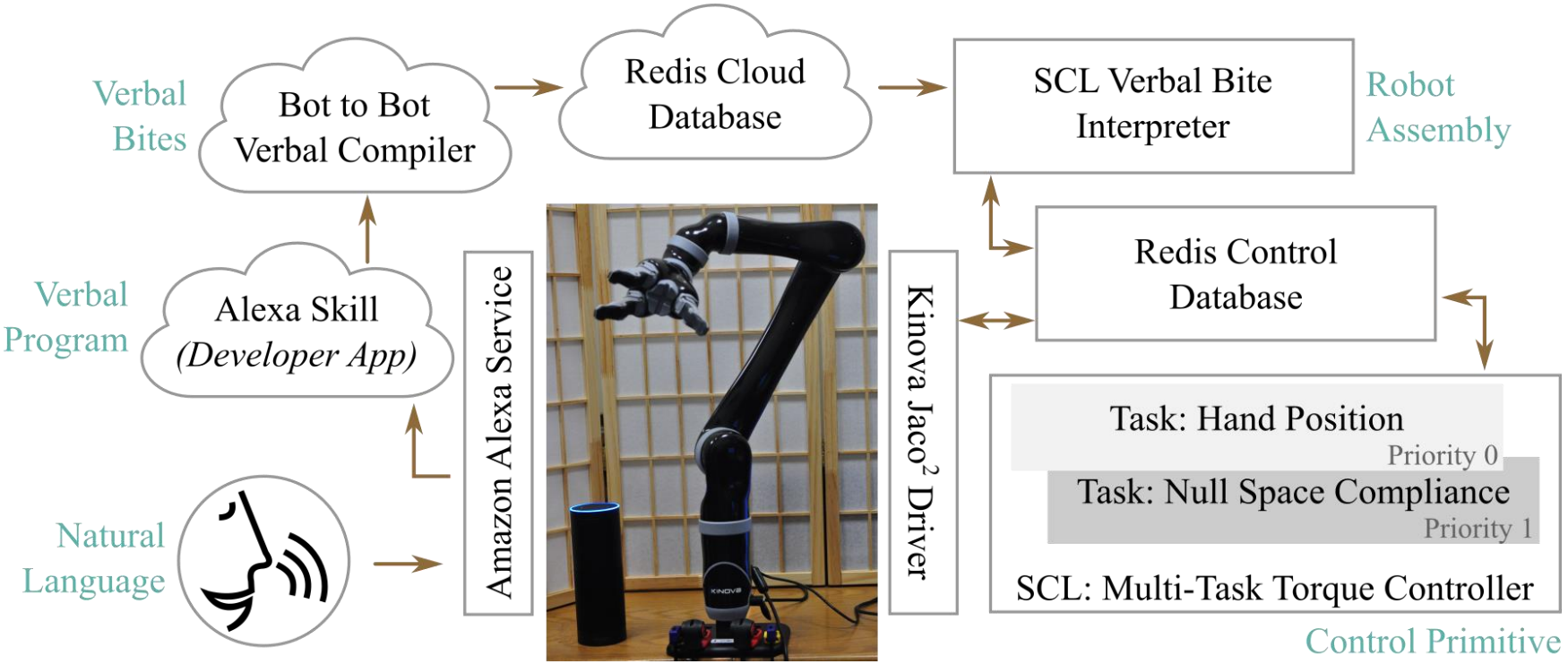
Behavior modifications require extensive low-level programming

Vision: Fluid verbal HRI in real-time

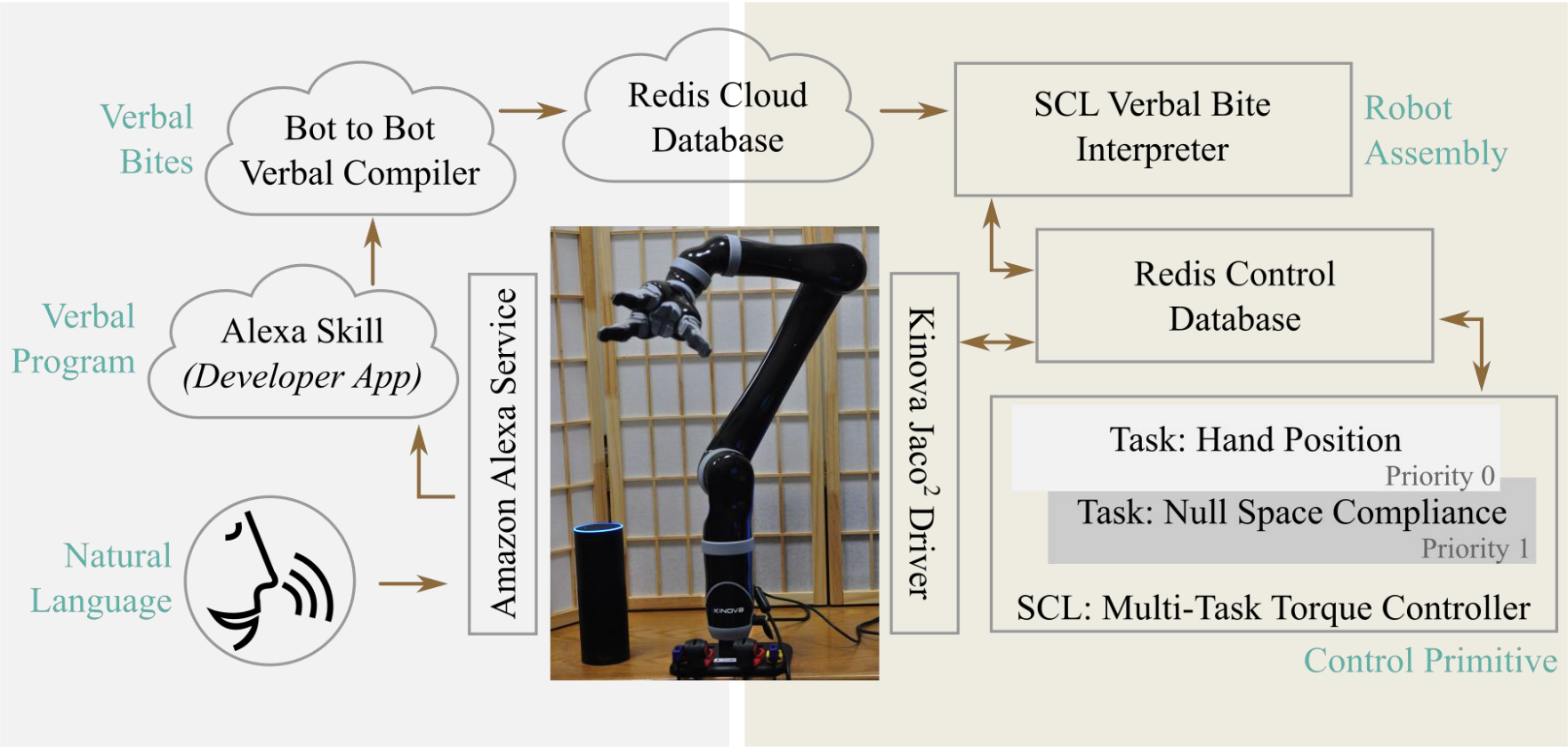
Robot, scratch my back

Sure

Bot to Bot : Fluid verbal HRI in real-time



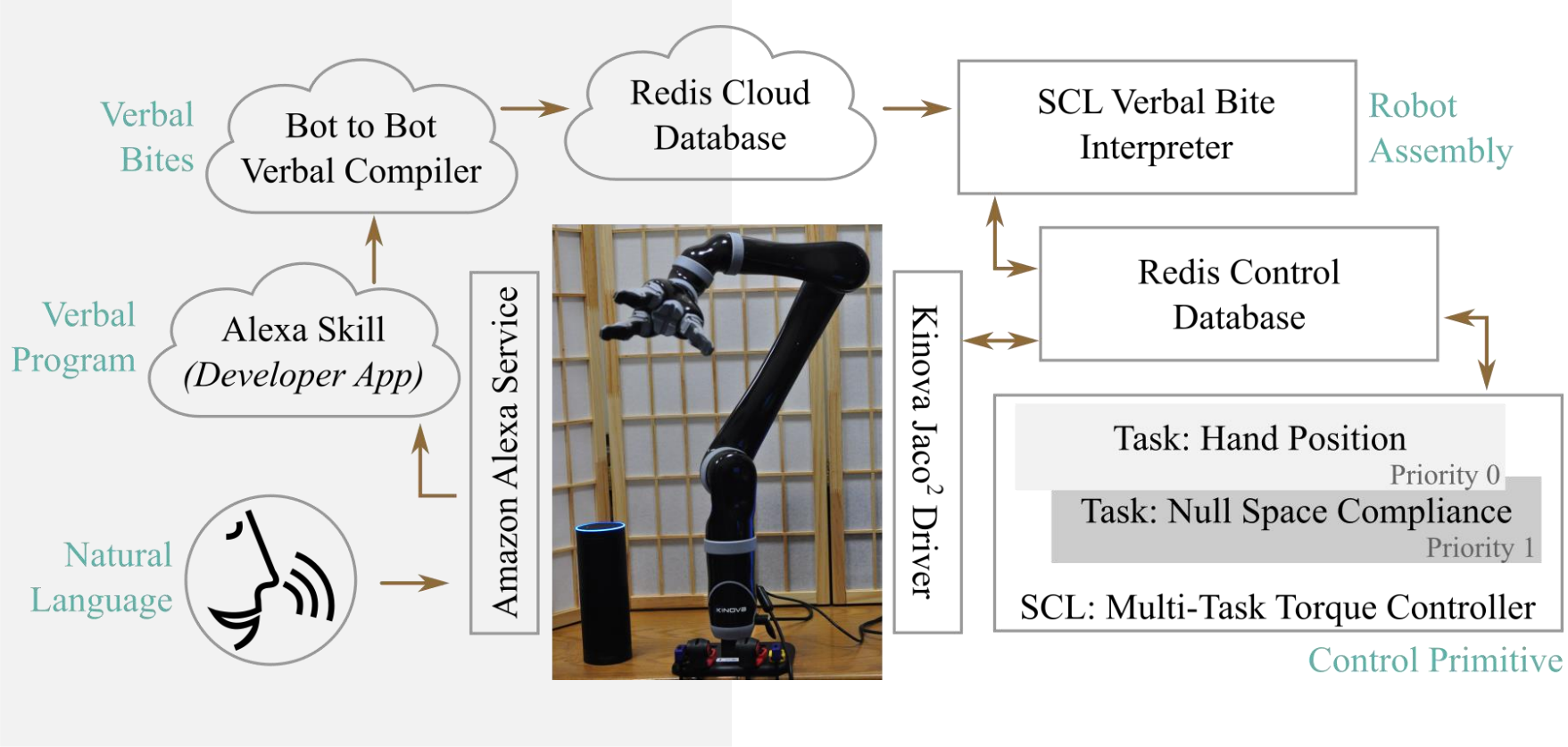
Natural language to Action



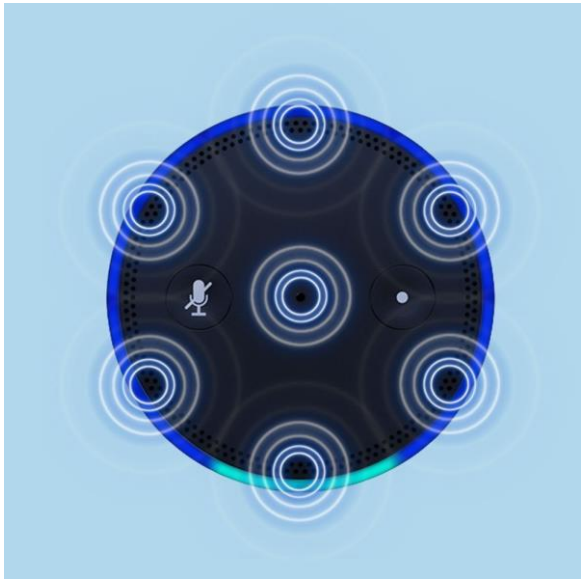
Chat bots

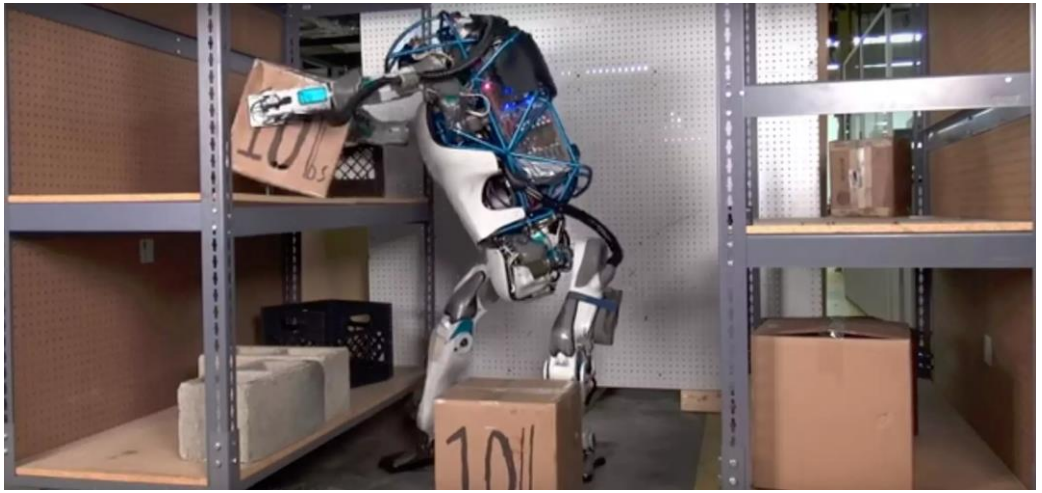
Robots

Chat bots : Interfacing with humans



Chat bots promise to unlock verbal communication





Chat bots are a growing field

Alexa chat bot & Kinova Jaco robot

Bot to Bot:

Let's enable chat bots to talk with robots!

An exemplar to explain the "Bot to Bot" system

Instantiation	*Stage*
"Alexa tell the robot to wake only me up at 7:00 am."	Natural Language
`{ "intent": "wake", "slots": { "time": "07:00" }, "code": ...setTimeout()... }`	Verbal Program
`{ "intent": "wake", "action": ["poke", "poke"] }`	Verbal Bite
`{ "action": "poke", "axis": "x", "motion": "sin(t)" }`	SCL Robot Assembly
`{ "Pri0": "Hand Position Task", "Pri1": "Null Space Compliance" }`	Control Primitive
Robot Arm Movement	Multi-task Controller

Stage 1: Natural Language to Verbal Program

Instantiation	*Stage*
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Overview: Translation from spoken *natural language* to a computer interpretable *verbal program*.

Natural language has many ways to convey an identical intent.

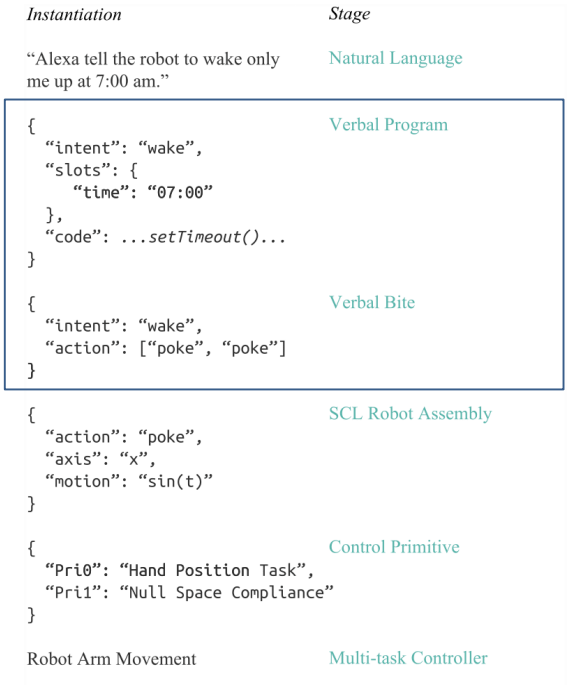
```
"wake me up at 7:00am"
"push me out of bed at 7:00am"
"make sure I'm awake at 7:00am"
```

Each of these is an utterance that is provided by the developer.

Utterances are used to train a linguistic model.

User don't have to exactly match an utterance.

Stage 2: Verbal Program to Verbal Bite



Overview: Allow for a separation between application programmer and robot programmer.

Verbal Programs contain traditional programmer logic, such as:

```
Do [Verbal Bite] if Y.
Do [Verbal Bite] when Y.
Do [Verbal Bite] at 7:00am.
```

Verbal Bites are compounded movements the robot can take, such as:

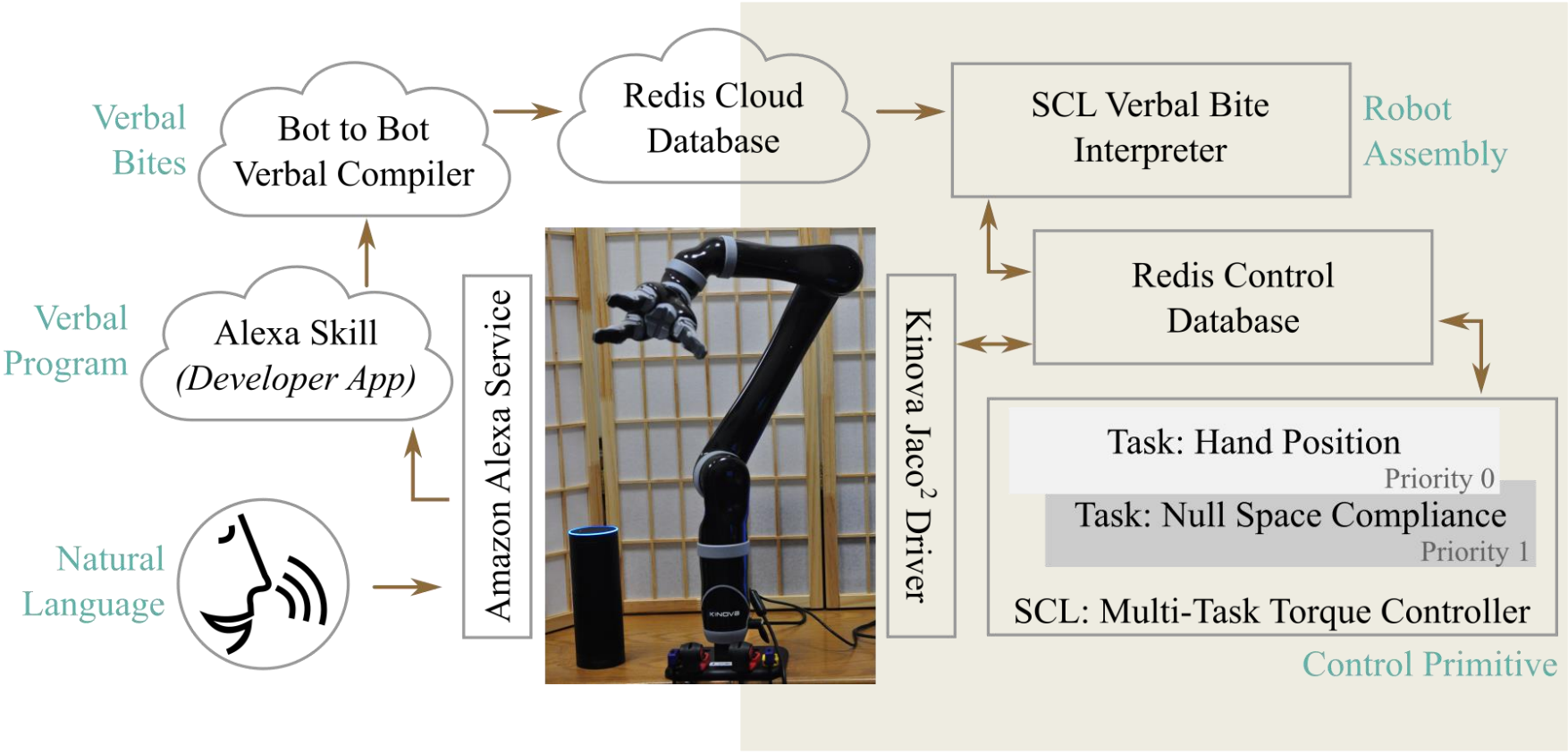
Pat, Move, Wave, Poke, Scratch

Simplifies software development and encourage code reuse.

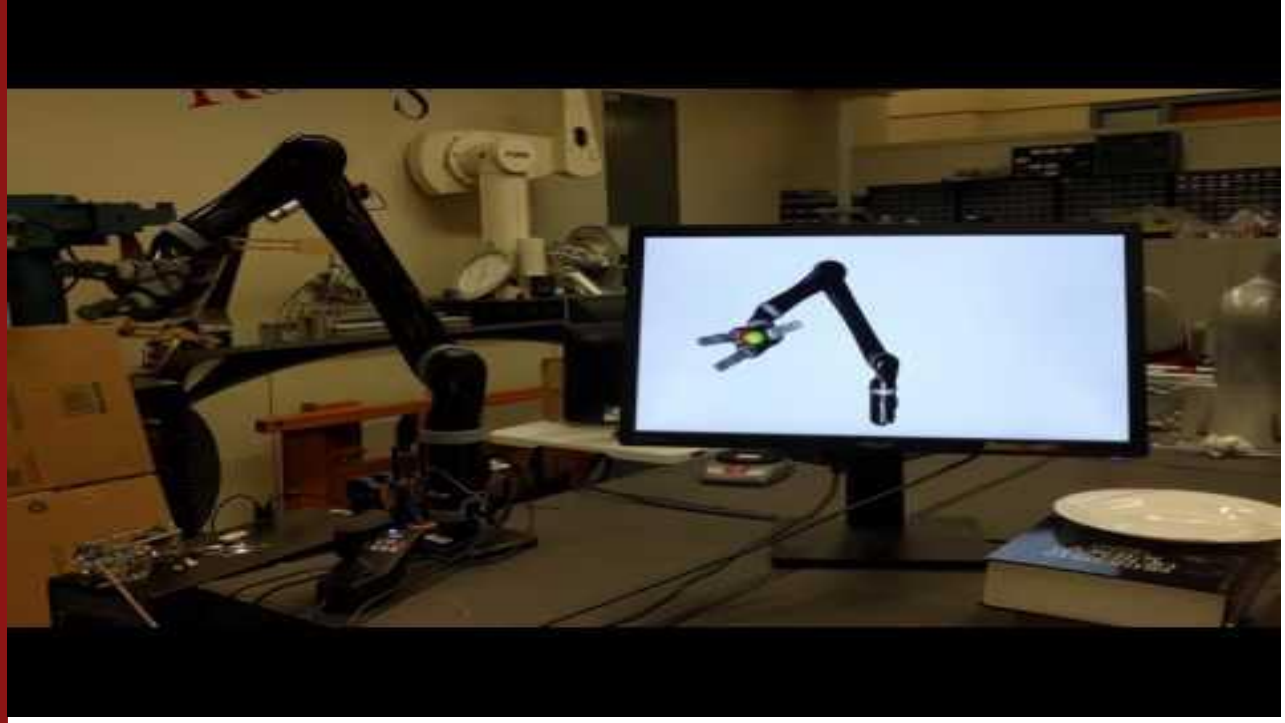
We've parsed natural language to an intermediate representation...

Now let's map it to robot actions...

Robots : Interface with the physical environment



How do we program robots?

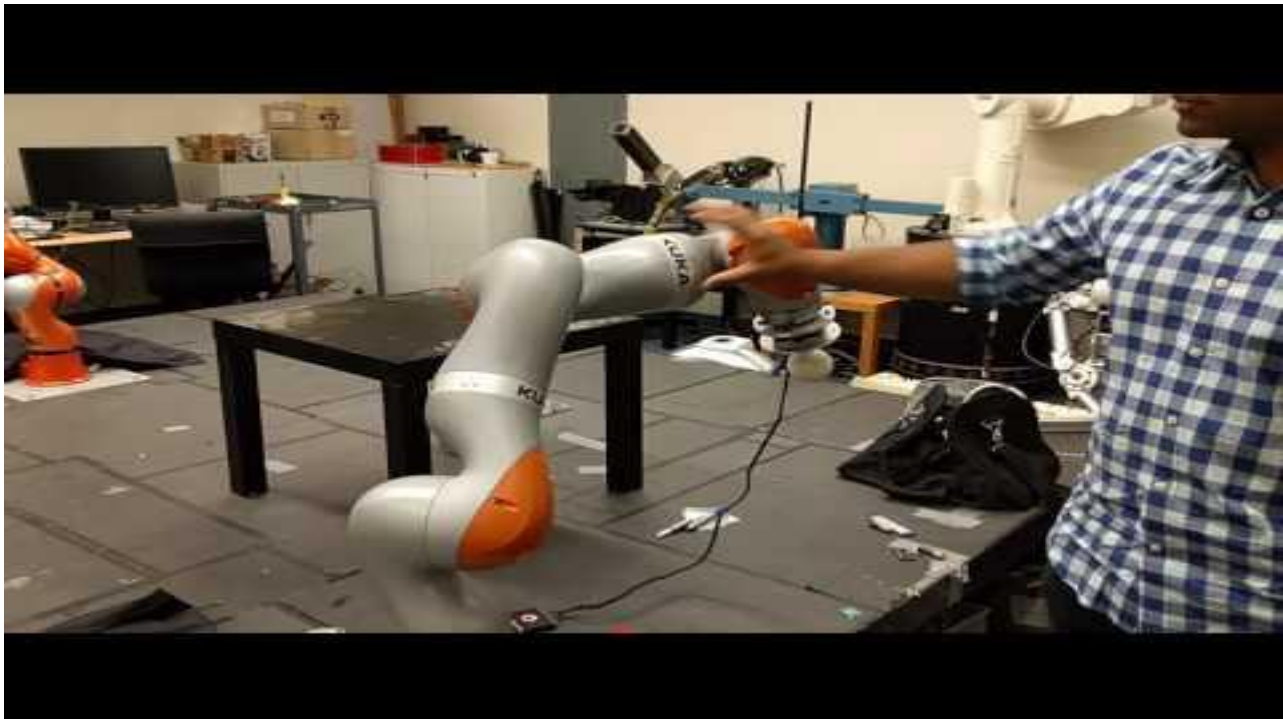


Kinova Jaco
(6dof) :
Human instructed
trajectory tracking

Robot class : Serial
chain manipulator

Kuka LBR IIWA
(7dof):
Human guided
motions

Robot class : Serial
chain manipulator



Robot programming involves low level motion specifications.

We need to bridge the gap between natural language and robot programming...

Robots receive high-level task sequences

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Robot Arm Movement	Multi-task Controller

Sequence of tasks (a finite state machine)

Yet require low-level force and motion commands

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Sequence of tasks (a finite state machine)

?

Low level force and motion control

Solution: Intermediate stages to simplify mapping

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Sequence of tasks (a finite state machine)

Robot agnostic task specification

Robot specific control primitive

Low level force and motion control

Let's step back to our Bot to Bot stages...

Stage 3: Verbal Bite to SCL Robot Assembly

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Overview:

Robot assembly is a specific robot-agnostic mathematical operation with information that allows a robot to execute the operation.

Allow for robot agnostic programs and force control specifications.

Stage 4: Robot Assembly to Control Primitive

Instantiation	*Stage*
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Robot Arm Movement	Multi-task Controller

Overview:

Control primitives are semi-autonomous programs that can completely specify motor tasks for a class of robots (say humanoids, or robot arm manipulators).

Robot-specific task components are limited to robot structure and capability (not low level sensors and I/O).

Stage 5: Control Primitive to Multi-task Controller

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Overview:

This stage compiles programs meant for a class of robots into very specific control commands for a specific robot.

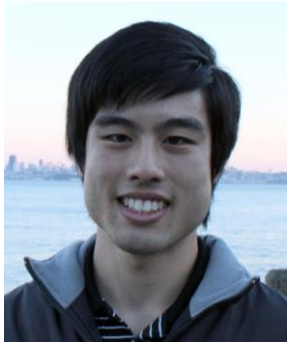
So we have all the pieces of the puzzle.

Let's take a moment to see how the system works in real-time...

Future steps : Much to be done...

Acknowledgements

Vinay Sriram



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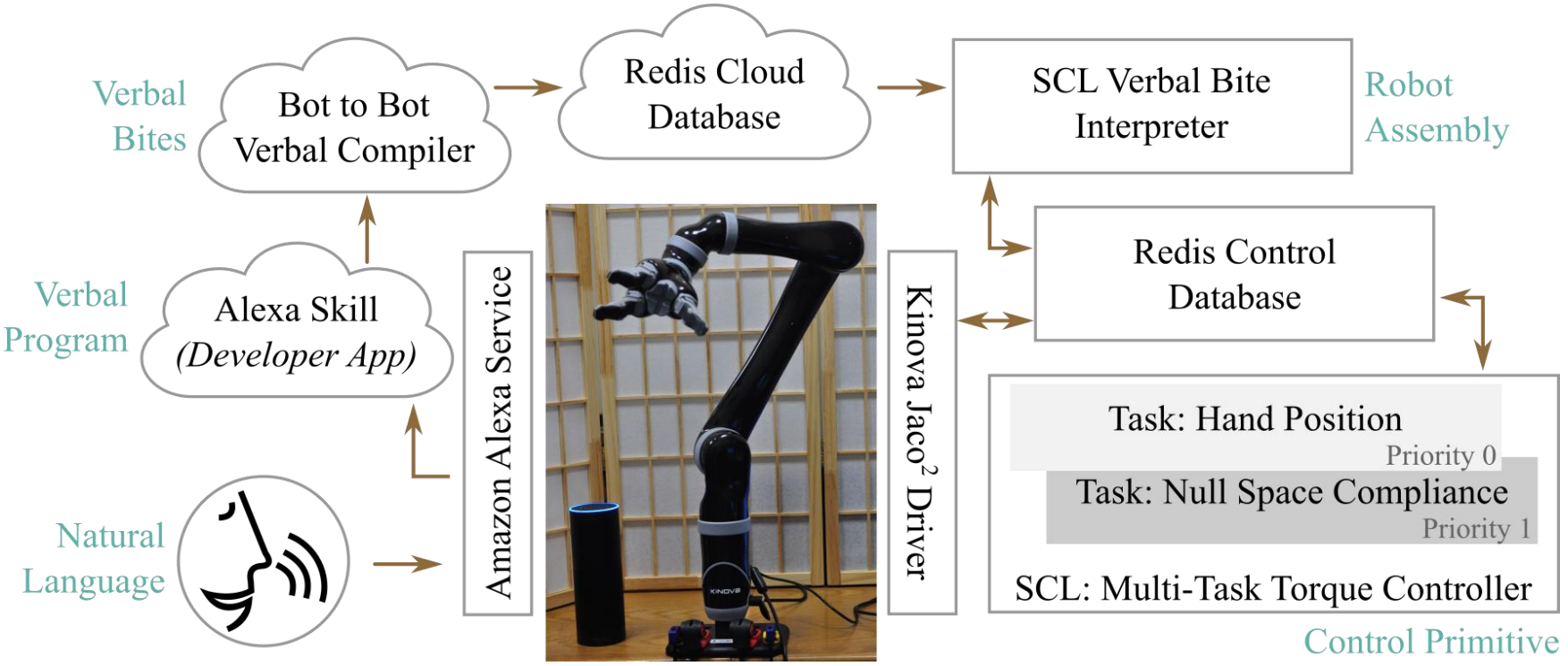
BIO-X

You have questions? We give you answers...



Fin.