Tekkotsu Behaviors & Events

15-494 Cognitive Robotics

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Disclaimer

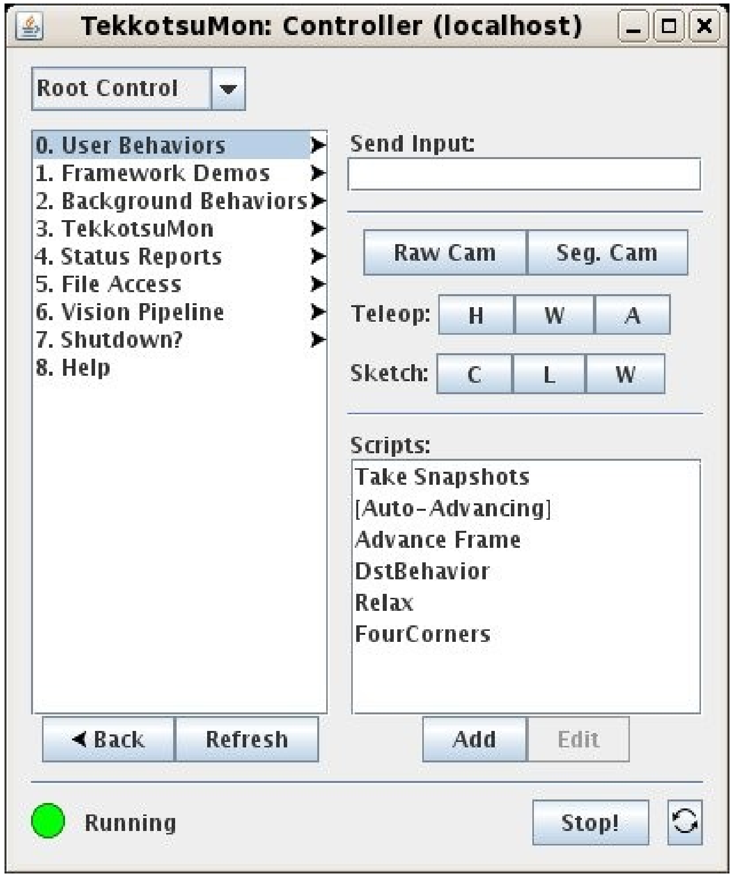
- This lecture will show you how Tekkotsu works at the basic level of behaviors and events.
- Some slides will contain...

ugly computer source code.

- Tekkotsu programmers don't really code this way.
- They use the state machine shorthand instead.
- That's the next lecture.

Behaviors

- Behaviors are *classes* defined in .h files:
  - Add them to the ControllergGUI “User Behaviors” menu using the REGISTER_BEHAVIOR macro
  - Double click on the “User Behaviors” menu item to instantiate and run
  - When you stop a behavior (double click on the menu item again), the instance is deleted



Five Behavior Components

```
#include “Behaviors/BehaviorBase.h”

class PoodleBehavior : public BehaviorBase {
```

- Constructor

```
 PoodleBehavior() : BehaviorBase(“PoodleBehavior”) {}
```

- DoStart() is called when the behavior is activated

```
  virtual void doStart() {
    cout << getName() << “ is starting up.” << endl;
  }
```

Five Behavior Components

- DoStop() is called when the behavior is deactivated, but you rarely need to bother with this.

```
virtual void doStop() {
   cout << getName() << “ is shutting down.” << endl;
 }
```

- doEvent processes requested event types

```
virtual void doEvent() {
   cout << getName() << “ got event: “
        << event->getDescription() << endl;
 }
```

Five Behavior Components

- getClassDescription() returns a string displayed by ControllerGUI pop-up help

```
    virtual std::string getClassDescription() {
      return “Demonstration of a simple behavior”;
    }


};  // end of PoodleBehavior class definition
```

Behaviors are Coroutines

- Behaviors are coroutines, not threads:
  - Many can be “active” at once, but...
  - Only one is actually running at a time.
  - No worries about mutual exclusion.
  - Must voluntarily relinquish control so that other active behaviors can run.
- BehaviorBase is a subclass of:
  - EventListener
  - ReferenceCounter
- Behaviors will be deleted if they are deactivated and the reference count goes to zero.

Browsing the Documentation

- Go to Tekkotsu.org and click on “Reference” in the gray nav bar.
- “Class List” in the left nav bar
  - Click on a class name (`BehaviorBase`) to see documentation
  - Then click on a method name (`processEvent`) to jump to detailed description
  - Click on line number to go to source code
- “Directories” in left nav bar shows major components
  - Look at the `Behaviors` and `Events` directories

Searching the Source

- The “search” box in the online documentation can be used to search for classes, methods, variables, enumerated types, etc.

- Use the “ss” shell script to grep the source code:

```
> cd /usr/local/Tekkotsu

> ss RMdLeg

> ss IRDist
```

Events

- Events are subclasses of `EventBase`
- Three essential components:

Generator ID: what kind of event is this?

buttonEGID, visionEGID, timerEGID, ...

Source ID: which sensor/actuator/behavior/thing generated this event?

ChiaraInfo::GreenButOffset

ERS7Info::HeadButOffset

Type ID, which must be one of:

activateETID

statusETID

deactivateETID

Where are these Defined?

- EventGeneratorID_t defined in EventBase.h
- EventTypeID_t defined in EventBase.h

```
enum EventTypeID_t {
    activateETID,
    statusETID,
    deactivateETID,
    numETIDs
  };
```

- Event source ids are specific to the event type:
  - GreenButOffset defined in ChiaraInfo.h
  - visPinkBallSID defined in ProjectInterface.h

Subscribing to Events

addListener(*listener*,*generator*,*source*,*type*)

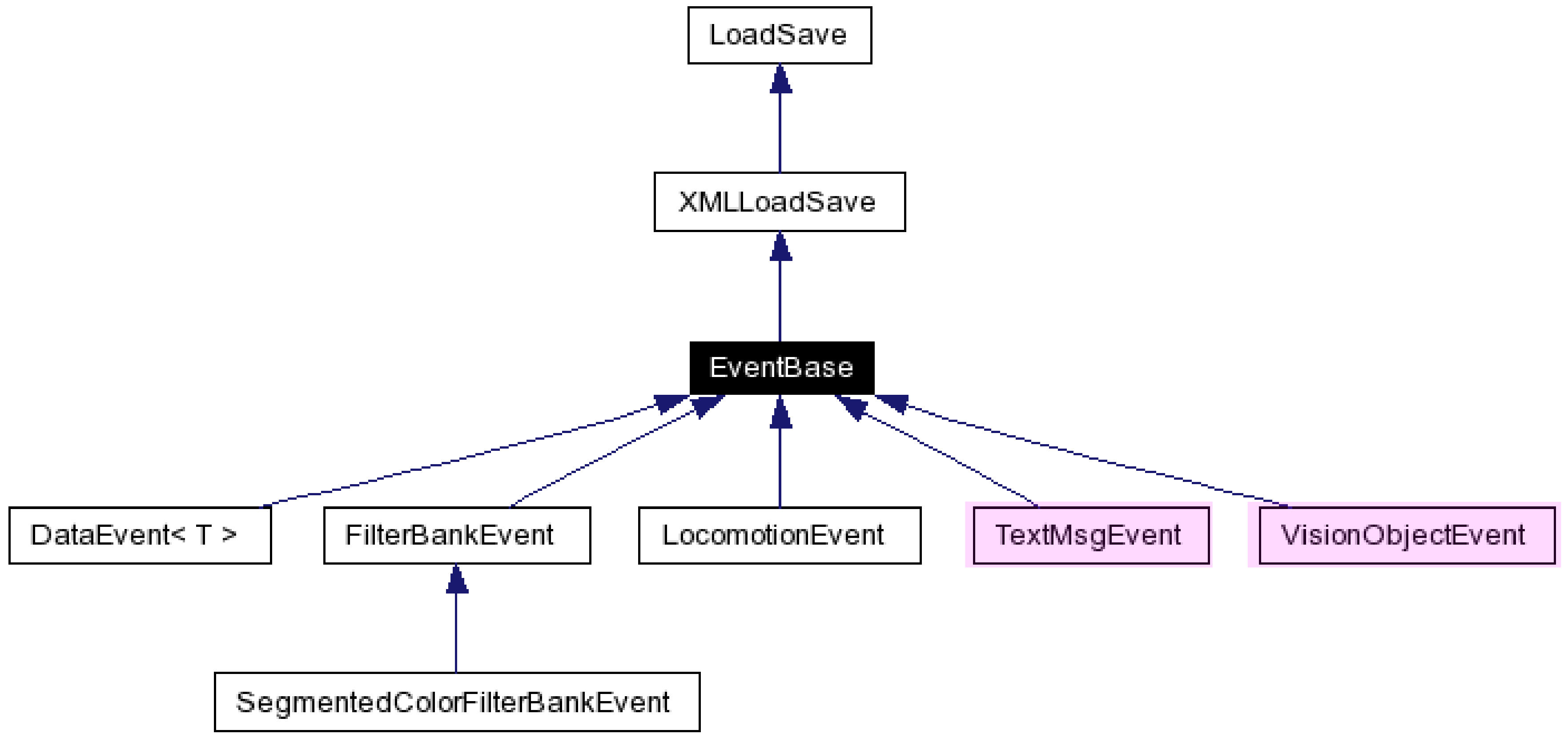
```
#include “EventRouter.h”

virtual void doStart() {
  erouter->addListener(this,
                       EventBase::buttonEGID,
                       RobotInfo::GreenButOffset,
                       EventBase::activateETID);
}
```

Processing Events

```
virtual void doEvent() {
  switch ( event->getGeneratorID() ) {

    case EventBase::buttonEGID:
      cout << “Button press: “ << event->getDescription()
           << endl;
      break;

    default:
      cout << “Unexpected event: “
           << event->getDescription() << endl;
  }
}
```

Types of Events

- What are some subclasses of EventBase?

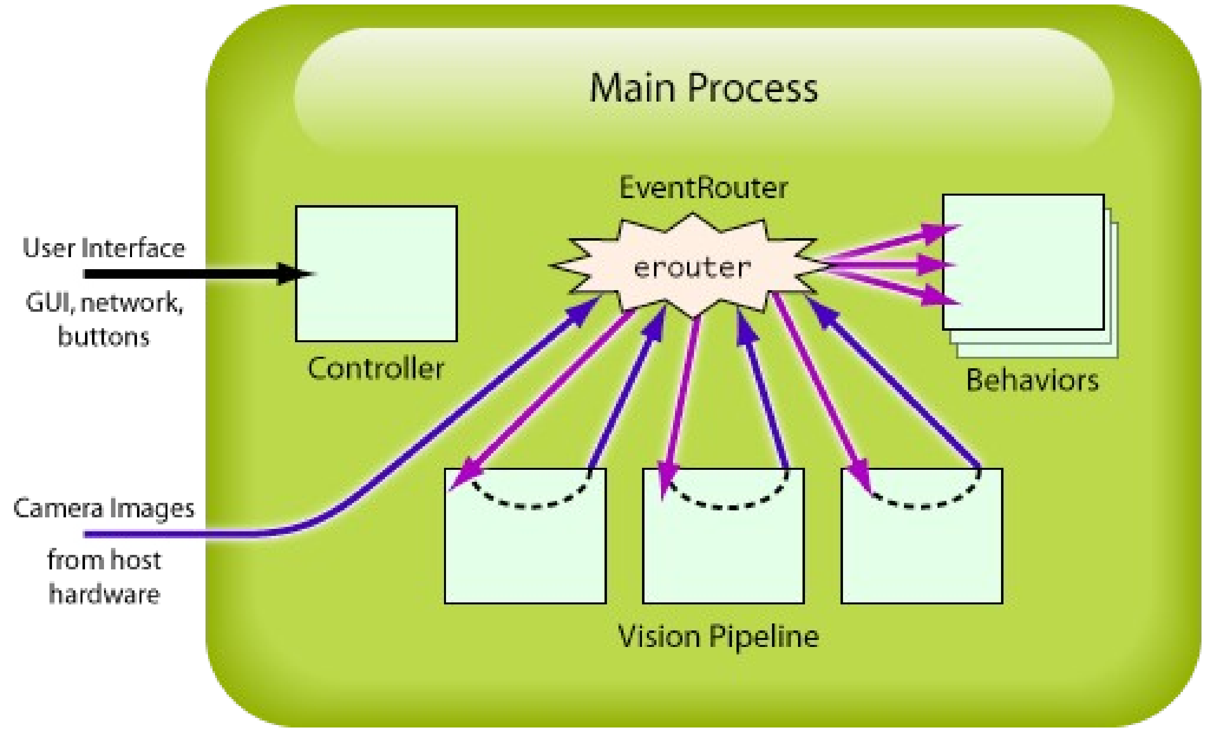


Vision Object Events

- VisionObjectEvent is a subclass of EventBase
- The vision pipeline includes an “object detector” that looks for pink roundish blobs, like a pink ball.
- The center and area of the largest blob are reported by posting a VisionObjectEvent (if anyone's listening.)
  - visObjEGID
  - visPinkBallSID
  - activate, status, deactivate ETIDs

The Event Router

- Runs in the Main process.
- Distributes events to the Behaviors listening for them.



Subscribing to Vision Events

```
#include “Events/VisionObjectEvent.h”
#include “Shared/ProjectInterface.h”


virtual void doStart() {
  erouter->addListener(this,
                      EventBase::visObjEGID,
                       ProjectInterface::visPinkBallSID);
}
```

Casting VisionObject Events

```
void doEvent() {
  switch ( event->getGeneratorID() ) {

  case EventBase::visObjEGID: {
    const VisionObjectEvent *visev =
      dynamic_cast<const VisionObjectEvent*>(event);
    if ( visev->getTypeID() == EventBase::activateETID ||
         visev->getTypeID() == EventBase::statusETID)
      cout << “Saw pink ball at (“
           << visev->getCenterX() << “, “
           << visev->getCenterY() << “)” << endl;
    else  // deactivate event
      cout << “Lost sight of the ball!” << endl;
    };
    break;

  case EventBase::buttonEGID:
    ...
```

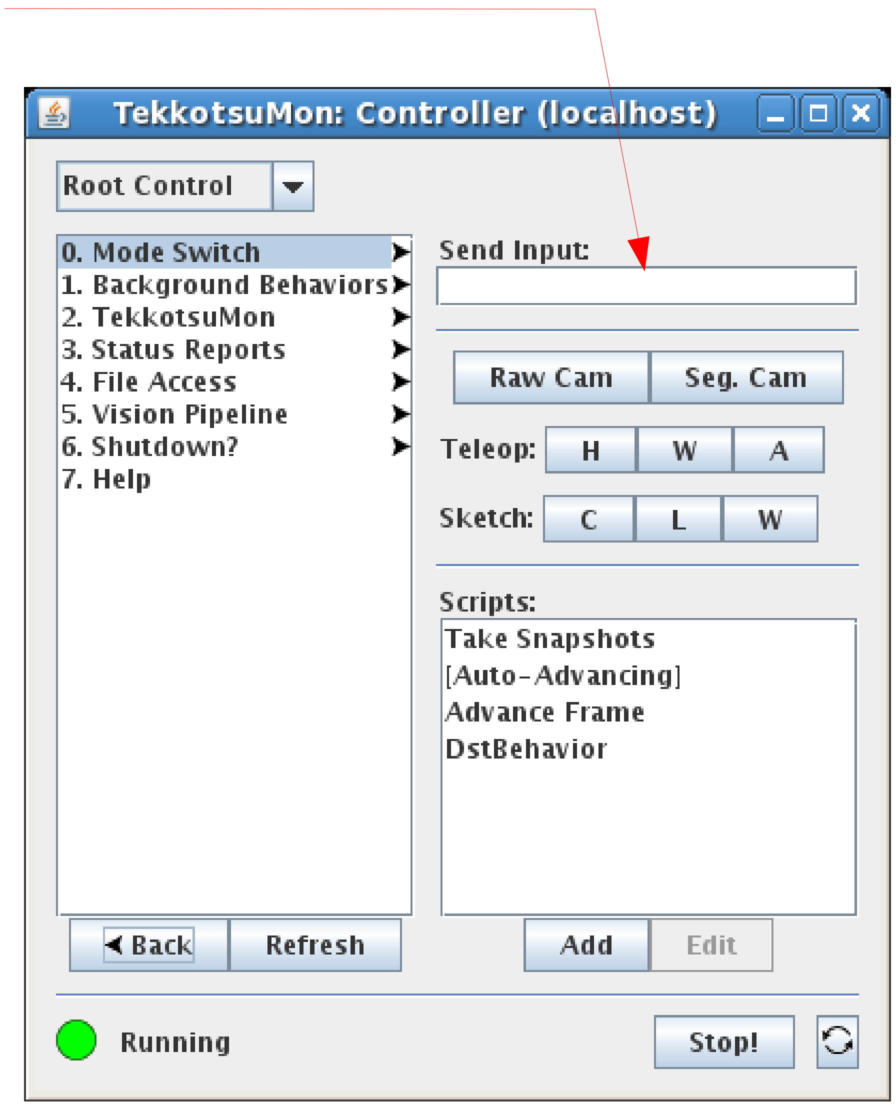
Text Message Events

You can send text messages to the AIBO via the ControllerGUI's “Send Input” window:

```
!msg Hi there
```

This causes the behavior controller to post a textmsgEvent.

You can also give the msg command to Tekkotsu's command line (with no exclamation point).



Subscribing to TextMsg Events

```
#include “Events/TextMsgEvent.h”

virtual void doStart() {
  erouter->addListener(this, EventBase::textmsgEGID);
}
```

The source ID is meaningless (it's -1).

The type ID is always statusETID.

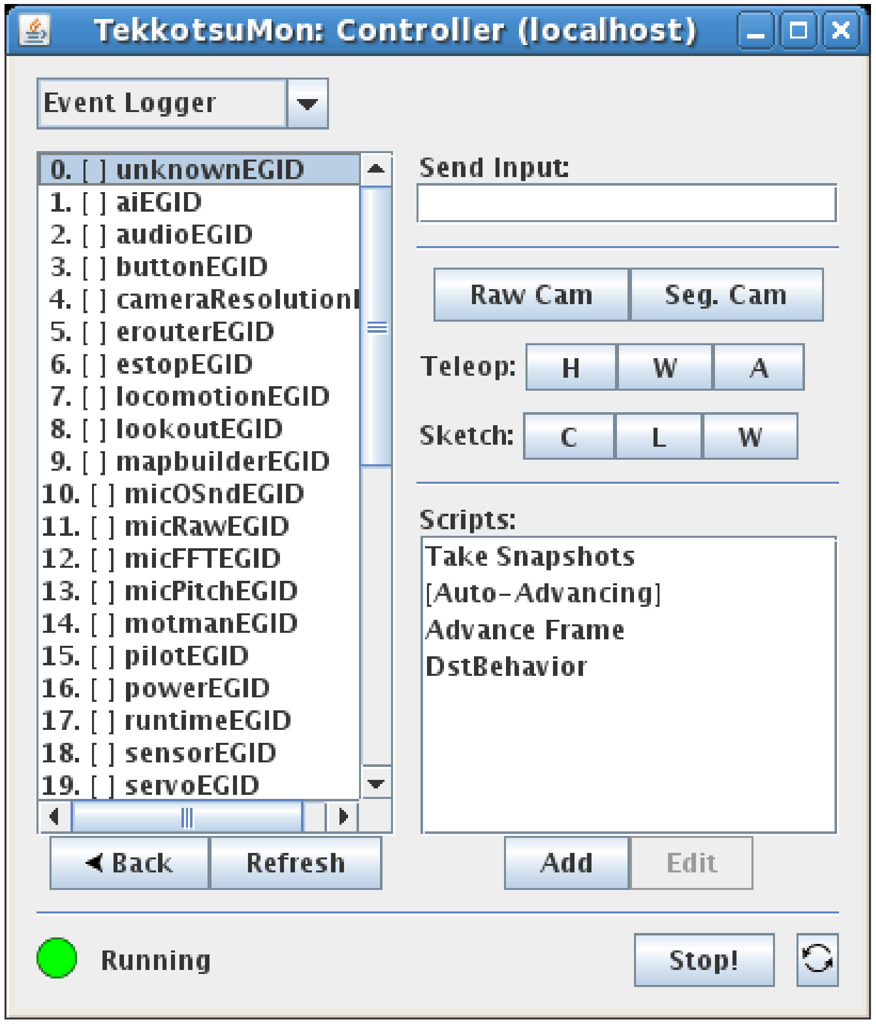
Casting TextMsg Events

```
void doEvent() {
 switch ( event->getGeneratorID() ) {

 case EventBase::textmsgEGID: {
  const TextMsgEvent *txtev =
   dynamic_cast<const TextMsgEvent*>(event);
  cout << “I heard: '” << txtev->getText() << “'” << endl;
  };
  break;

 case EventBase::buttonEGID:
  ...
```

The Event Logger

- Root Control
  - > Status Reports
    - > Event Logger

- Outputs to console



Timers

Timers are good for two kinds of things:

- Repetitive actions: “Bark every 30 seconds.”
  - Whenever a timer expires and a timer expiration event is posted, the timer should be automatically restarted.
- Timeouts: “If you haven't seen the ball for 5 seconds, bark and turn around.”
  - One-shot timer. Will need to be cancelled if we see the ball before the time expires.

addTimer

- addTimer(*listener*, *source*, *duration*, *repeat*)
  - listener is normally <u>this</u>
  - source is an arbitrary integer
  - duration is in milliseconds
  - repeat should be “true” if a sequence of timer events is desired
- Starts timer and automatically listens for the event.
- Timers are specific to a behavior instance; can use the same source id in other behaviors without interference.
- Behaviors can receive another's timer events if they use addListener to explicitly listen for them.
- removeTimer(*listener*, *source*)

Timer Example

```
#include “Behaviors/BehaviorBase.h”
#include “EventRouter.h”

virtual void doStart() {

  erouter->addListener(this,
                       EventBase::buttonEGID,
                       RobotInfo::GreenButffset,
                       EventBase::activateETID);

  erouter->addListener(this,
                       EventBase::buttonEGID,
                       RobotInfo::YellowButOffset,
                       EventBase::activateETID);
}
```

Timer Example

```
virtual void doEvent() {
  switch ( event->getGeneratorID() ) {

  case EventBase::buttonEGID:
    if ( event->getSourceID() == RobotInfo::GreenOffset )
      erouter->addTimer(this, 1234, 5000, false);
    else if (event->getSourceID() == RobotInfo::YellowButOffset)
      erouter->removeTimer(this, 1234);
  break;

  case EventBase::timerEGID:
    cout << “On no!!!!  Timer expired!” << endl;
  }

}
```

What does this behavior do?

Simulating Your Robot

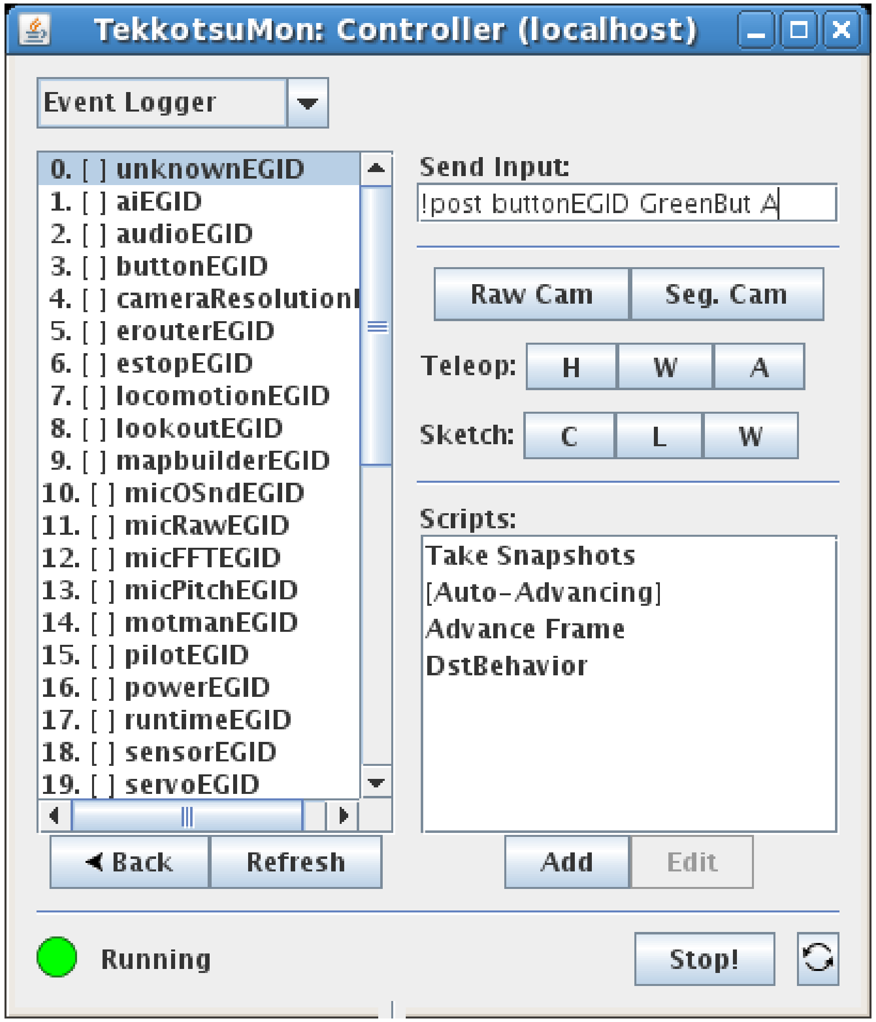
- For some robots, code is compiled right on the robot.
- If you want to simulate that robot on the PC, just install Tekkotsu on the PC and compile it there.
- Then you can direct Tekkotsu to use camera images and sensor values from a real robot that you previously saved to disk.
- Alternative (coming soon): the Mirage simulator provides a virtual environment in which you can run your simulated robot.

ControllerGUI Can Post Events to the Simulator

Type this command in the “Send Input” box:

```
!post buttonEGID GreenBut A
```

- Monitor the result using the Event Logger
- You can also use the post command in the Tekkotsu command line (no exclamation point).


TekkotsuMon: Controller (localhost)

Event Logger

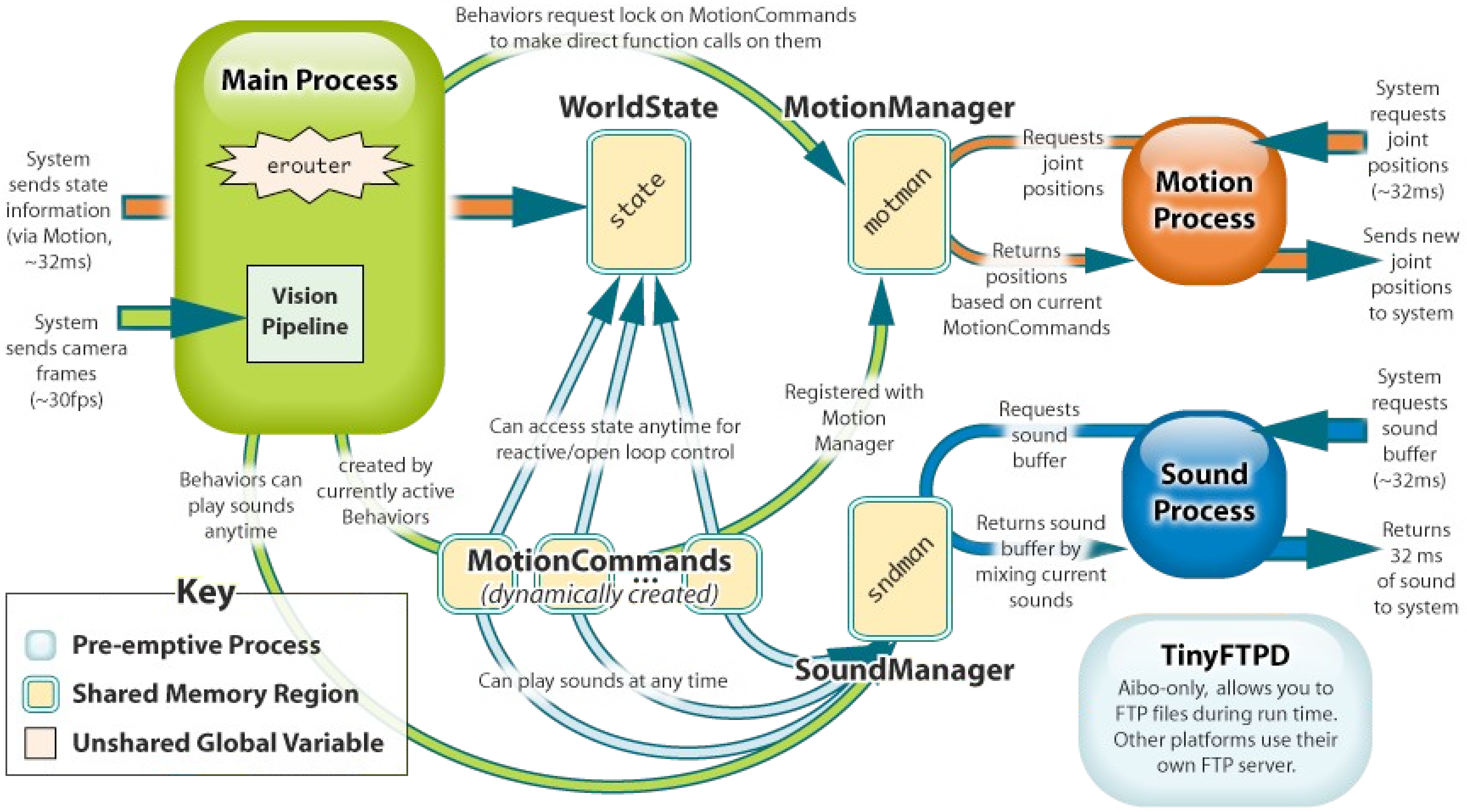
0. [ ] unknownEGID
1. [ ] aiEGID
2. [ ] audioEGID
3. [ ] buttonEGID
4. [ ] cameraResolutionI
5. [ ] erouterEGID
6. [ ] estopEGID
7. [ ] locomotionEGID
8. [ ] lookoutEGID
9. [ ] mapbuilderEGID
10. [ ] micOSndEGID
11. [ ] micRawEGID
12. [ ] micFFTEGID
13. [ ] micPitchEGID
14. [ ] motmanEGID
15. [ ] pilotEGID
16. [ ] powerEGID
17. [ ] runtimeEGID
18. [ ] sensorEGID
19. [ ] servoEGID

Send Input: !post buttonEGID GreenBut A

Scripts:
Take Snapshots
[Auto-Advancing]
Advance Frame
DstBehavior

Running

Tekkotsu Architecture: Main

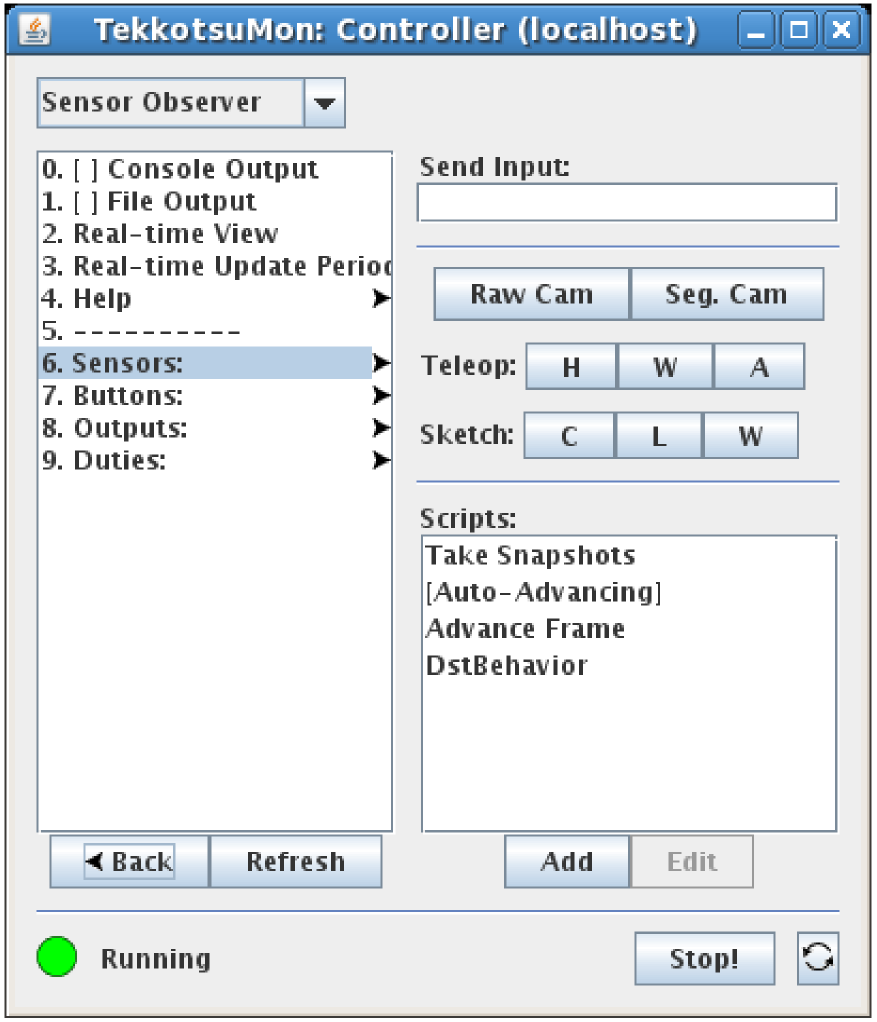

Behaviors request lock on MotionCommands to make direct function calls on them
Main Process
erouter
Vision Pipeline
System sends state information (via Motion, ~32ms)
System sends camera frames (~30fps)
WorldState
state
MotionManager
motman
Requests joint positions
Returns positions based on current MotionCommands
Motion Process
System requests joint positions (~32ms)
Sends new joint positions to system
Can access state anytime for reactive/open loop control
Registered with Motion Manager
Behaviors can play sounds anytime
created by currently active Behaviors
MotionCommands (dynamically created)
...
Requests sound buffer
Returns sound buffer by mixing current sounds
sndman
Sound Process
System requests sound buffer (~32ms)
Returns 32 ms of sound to system
Can play sounds at any time
SoundManager
TinyFTPD
Aibo-only, allows you to FTP files during run time. Other platforms use their own FTP server.
Key
Pre-emptive Process
Shared Memory Region
Unshared Global Variable

World State

- Shared memory structure between Main and Motion
- Updated every 32 msec
- sensorEGID events announce each update
- Contents:
  - joint positions, duty cycles, and PID settings
  - button states: `state->buttons[GreenButOffset]`
  - IR range readings: `state->sensors[CenterIRDistOffset]`
  - accelerometer readings (if installed)
  - battery state, thermal sensor
  - commanded walking velocity (x,y,a)

Sensor Observer

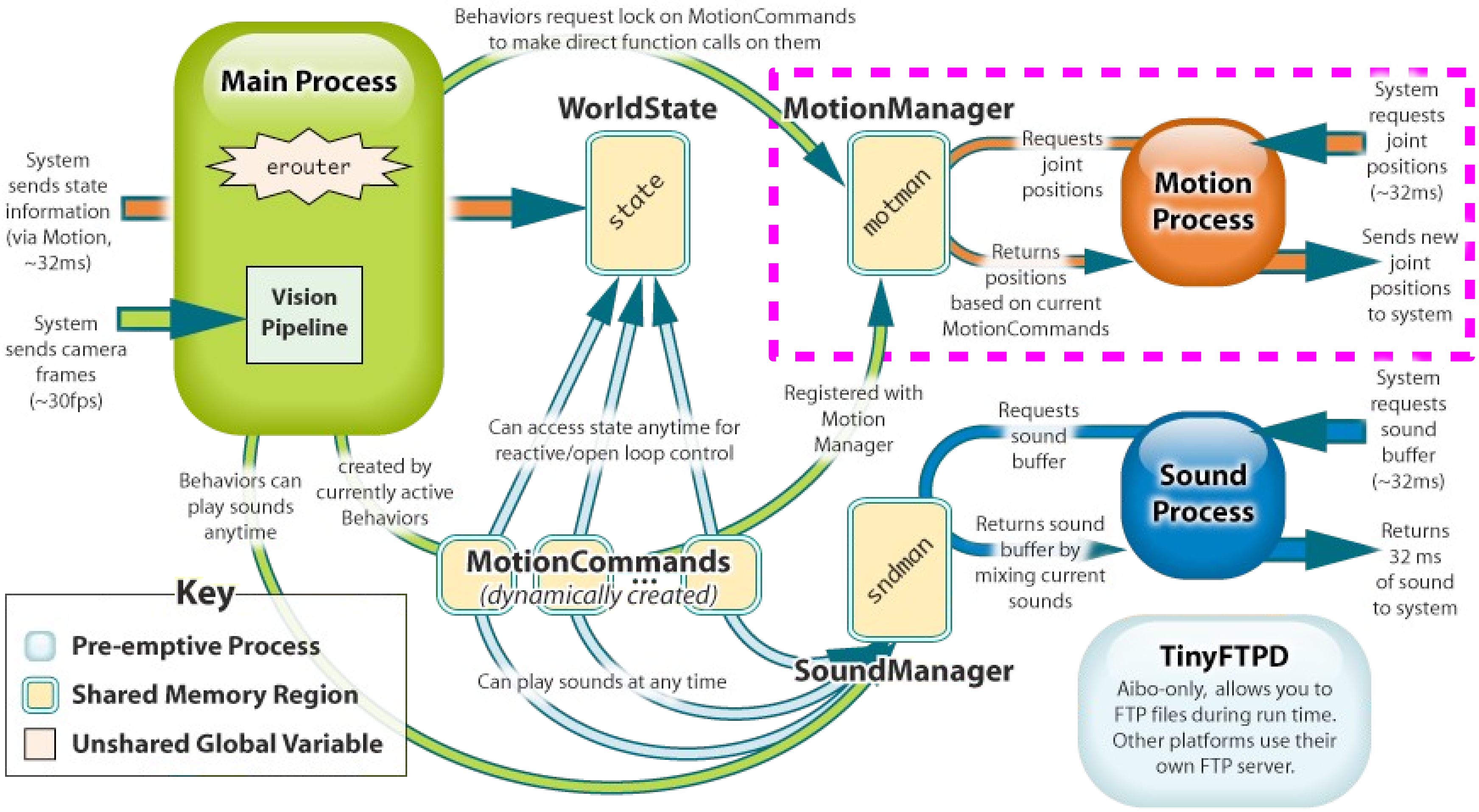
- Root Control
  > Status Reports
    > Sensor Observer
- Try monitoring the IR range sensors.
- Then move your hand in front of the robot.



Control of Effectors

- How do we make the robot move?
- Must send commands to each device (head, legs, arm, LED display, etc.) every 32 ms.
- This is <u>real-time</u> programming.
- Can't spend too long computing command values!
- Best to do all this in another process, independent of user-written behaviors, so motion can be smooth.

Tekkotsu Architecture: Motion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