Tekkotsu

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an open source project created & maintained at Carnegie Mellon University

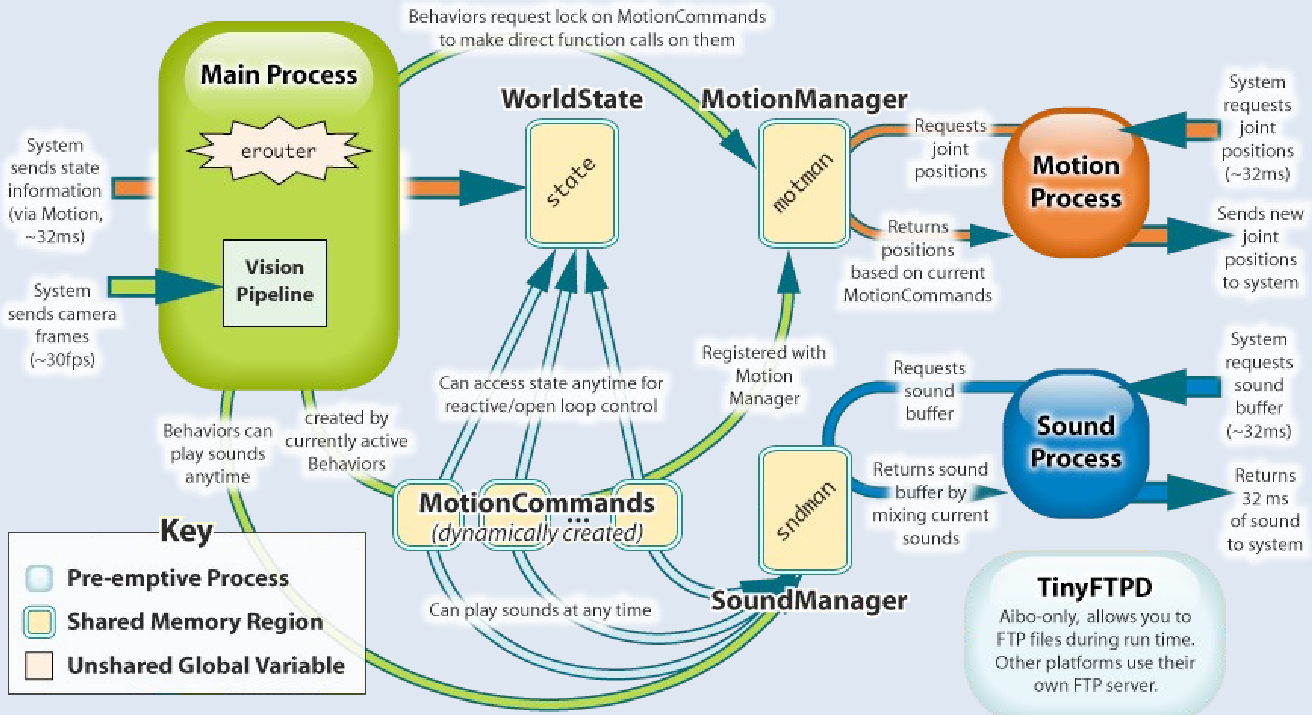
- Brian Thomas
- Robots for Education (Chad Jenkins)
- Brown University
- Spring 2011
- Images courtesy of www.tekkotsu.org, www.robotshop.com

Core aims/motivations

- Handle routine low-level robot tasks
- Let developers focus on high-level programming
- Originally developed for AIBO but now supports a larger number of platforms.

Approach taken by Tekkotsu

- **Framework** for robot software development
- **Libraries** for routine tasks
- Made at **CMU**; licensed under the **LGPL**


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)
...
Can play sounds at any time
SoundManager
sndman
Requests sound buffer
Returns sound buffer by mixing current sounds
Sound Process
System requests sound buffer (~32ms)
Returns 32 ms of sound to system
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

Tekkotsu's design

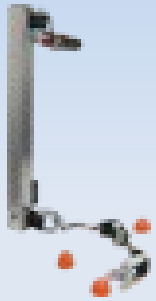
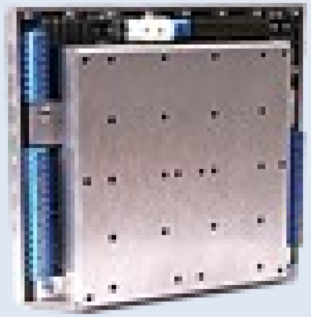
- **"Performance and low overhead are important design considerations."**
    - Tekkotsu website
- Object-oriented
- Event-passing
- Want to expose both high-level and low-level controls
- **=> uses C++**

Services Provided

- Visual processing
- Localization
- Forward/Inverse kinematics
- Real-time motion control
- Teleoperation

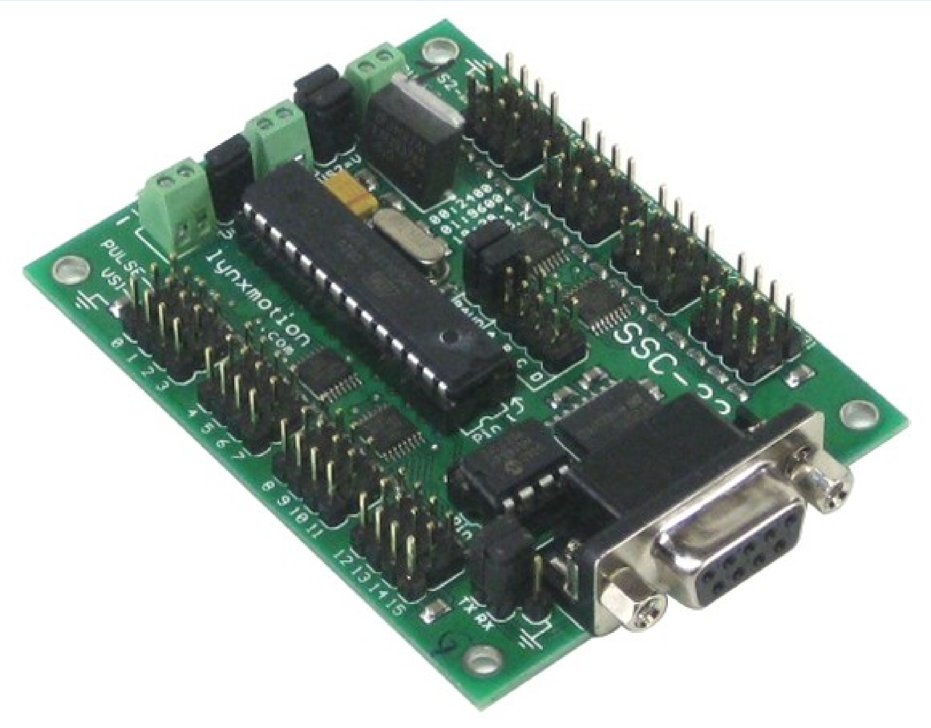
Supported Robots

- Aibo
- iRobot Create
- Chiara
- HandEye
- Lynxmotion Arms
- Qwerk

Supported Hardware

- Cameras (using video4linux)
- **Lynxmotion SSC-32 servo controller**
- Lynxmotion pan/tilt controller
- Bioloid actuators



Supported Algorithms

- State Machines (with a GUI viewer, Storyboard)
- Kinematics
- Dual coding (high-level computer vision routines)
- CMVision (color segmentation, blob detection)
- MapBuilder (2D)
- Particle Filtering
- Motion Modelling (dead reckoning)
- Tone/pitch detection
- Random number generator

Tekkotsu uses lots of 3rd party code

- NEWMAT (matrix operations), libjpeg, libpng, libxml2, and zlib
- CMVision package by Jim Bruce for color segmentation and region grouping
- Aibo walk engine from Manuela Veloso’s 2002 RoboSoccer entry, CMPack’02

Where is Tekkotsu used?

- Past classes (Spring 2007 and previous)
  - **Carnegie Mellon University** (David Touretzky - Cognitive Robotics)
  - **University of Alberta** (Michael Bowling - CMPUT412: Experimental Mobile Robotics)
  - **SUNY Albany** (Prof. Tomek Strzalkowski - Robotics Seminar, Spring 2005)
  - **University of Pittsburgh** (Prof. Donald Chiarulli - CS 1567: Programming and System Design using a Mobile Robot)
  - **Lehigh University** (John Spletzer - CSE398/498, Spring 2005)
- And, apparently, some current classes as well.

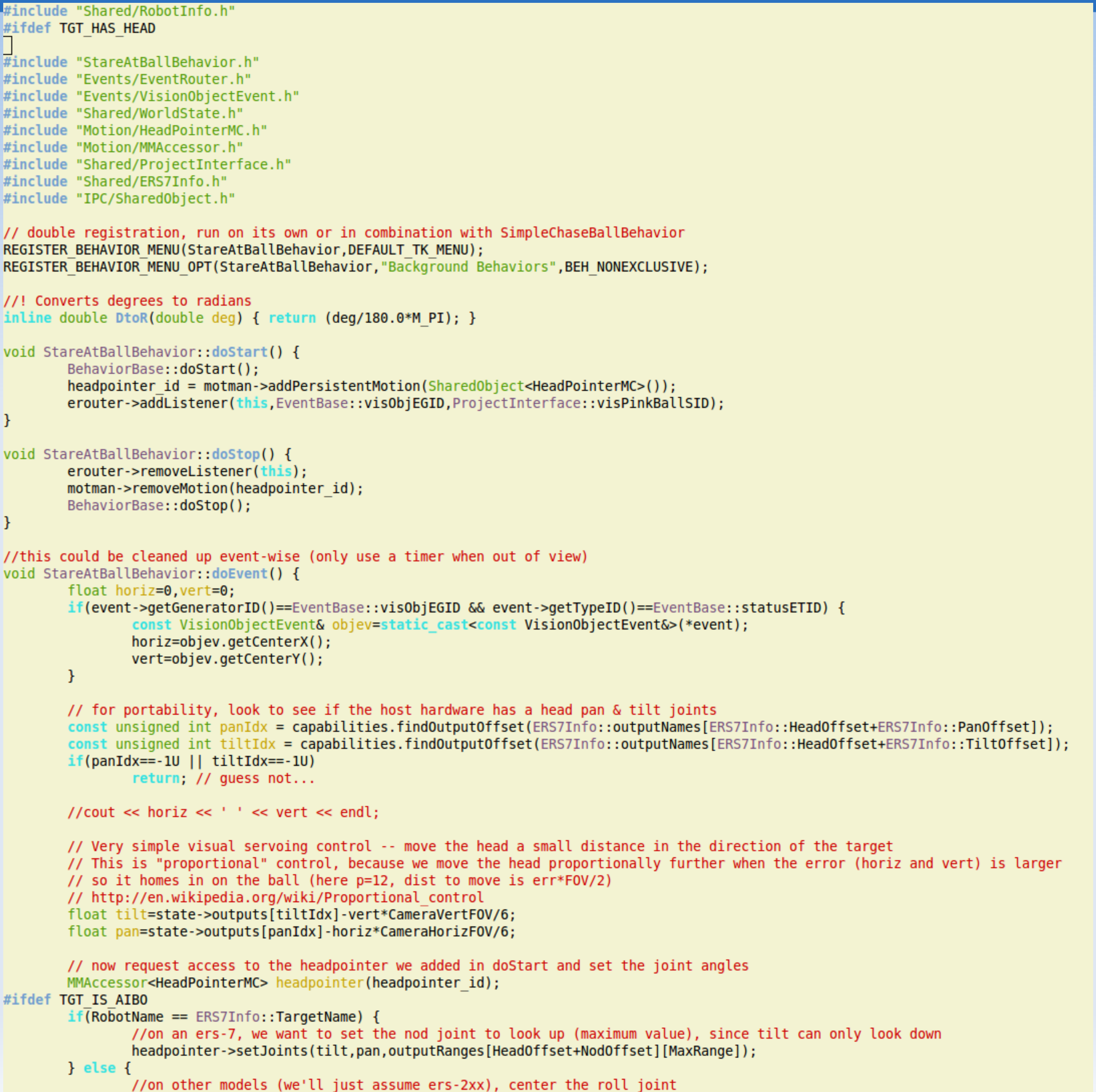
Where is Tekkotsu used?

- Lots of **research institutions** have used (and maybe still use) it...
- Bar-Ilan University - Israel
- Carnegie Mellon University Tekkotsu Lab - U.S.
- City University of Hong Kong - Hong Kong
- Dutch ARchitecture Project for Aibos (DARPA) - Netherlands
- Instituto Superior Técnico - Instituto de Sistemas e Robótica - Portugal
- Lawrence Technological University - U.S.
- Lehigh University - U.S.
- Lund University - Sweden
- National University of Singapore – Singapore
- Spelman College - U.S.
- SUNY Albany - U.S.
- Università degli Studi di Messina - Italy
- University of Alberta (2)- Canada
- University of Applied Sciences Gießen-Friedberg - Germany
- University of Edinburgh - Scotland
- University of Iowa - U.S.
- University of Minnesota - U.S.
- University of New Orleans Robotics - U.S.
- University of Pittsburgh - U.S.
- Uppsala University - Sweden

System Demo

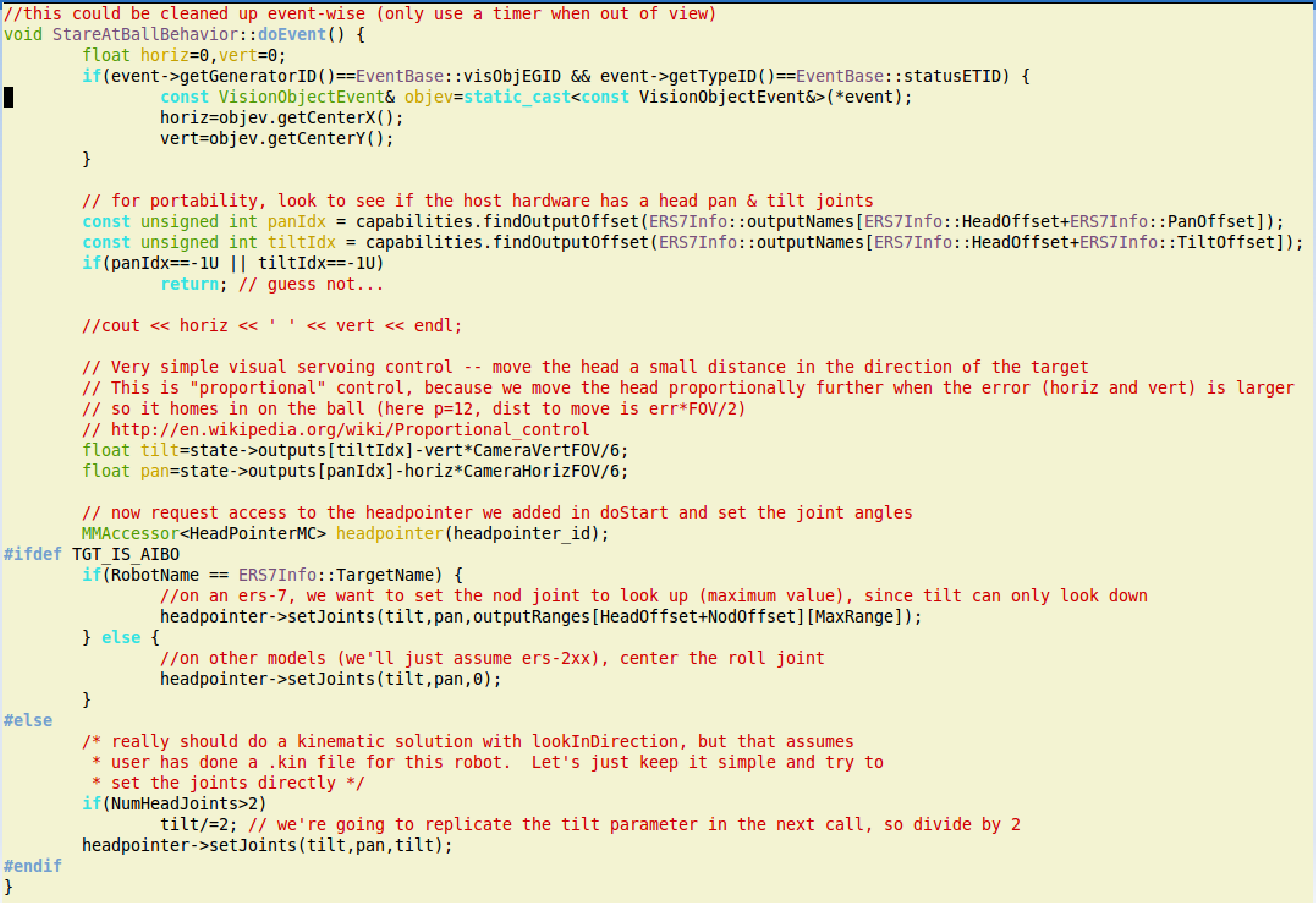
- ...after the talk, due to wireless configuration.
  - AIBOs communicate with a host computer through a common router.

Code Walkthrough



```
#include "Shared/RobotInfo.h"
#ifdef TGT_HAS_HEAD

#include "StareAtBallBehavior.h"
#include "Events/EventRouter.h"
#include "Events/VisionObjectEvent.h"
#include "Shared/WorldState.h"
#include "Motion/HeadPointerMC.h"
#include "Motion/MMAccessor.h"
#include "Shared/ProjectInterface.h"
#include "Shared/ERS7Info.h"
#include "IPC/SharedObject.h"

// double registration, run on its own or in combination with SimpleChaseBallBehavior
REGISTER_BEHAVIOR_MENU(StareAtBallBehavior,DEFAULT_TK_MENU);
REGISTER_BEHAVIOR_MENU_OPT(StareAtBallBehavior,"Background Behaviors",BEH_NONEXCLUSIVE);

//! Converts degrees to radians
inline double DtoR(double deg) { return (deg/180.0*M_PI); }

void StareAtBallBehavior::doStart() {
        BehaviorBase::doStart();
        headpointer_id = motman->addPersistentMotion(SharedObject<HeadPointerMC>());
        erouter->addListener(this,EventBase::visObjEGID,ProjectInterface::visPinkBallSID);
}

void StareAtBallBehavior::doStop() {
        erouter->removeListener(this);
        motman->removeMotion(headpointer_id);
        BehaviorBase::doStop();
}

//this could be cleaned up event-wise (only use a timer when out of view)
void StareAtBallBehavior::doEvent() {
        float horiz=0,vert=0;
        if(event->getGeneratorID()==EventBase::visObjEGID && event->getTypeID()==EventBase::statusETID) {
                const VisionObjectEvent& objev=static_cast<const VisionObjectEvent&>(*event);
                horiz=objev.getCenterX();
                vert=objev.getCenterY();
        }

        // for portability, look to see if the host hardware has a head pan & tilt joints
        const unsigned int panIdx = capabilities.findOutputOffset(ERS7Info::outputNames[ERS7Info::HeadOffset+ERS7Info::PanOffset]);
        const unsigned int tiltIdx = capabilities.findOutputOffset(ERS7Info::outputNames[ERS7Info::HeadOffset+ERS7Info::TiltOffset]);
        if(panIdx==-1U || tiltIdx==-1U)
                return; // guess not...

        //cout << horiz << ' ' << vert << endl;

        // Very simple visual servoing control -- move the head a small distance in the direction of the target
        // This is "proportional" control, because we move the head proportionally further when the error (horiz and vert) is larger
        // so it homes in on the ball (here p=12, dist to move is err*FOV/2)
        // http://en.wikipedia.org/wiki/Proportional_control
        float tilt=state->outputs[tiltIdx]-vert*CameraVertFOV/6;
        float pan=state->outputs[panIdx]-horiz*CameraHorizFOV/6;

        // now request access to the headpointer we added in doStart and set the joint angles
        MMAccessor<HeadPointerMC> headpointer(headpointer_id);
#ifdef TGT_IS_AIBO
        if(RobotName == ERS7Info::TargetName) {
                //on an ers-7, we want to set the nod joint to look up (maximum value), since tilt can only look down
                headpointer->setJoints(tilt,pan,outputRanges[HeadOffset+NodOffset][MaxRange]);
        } else {
                //on other models (we'll just assume ers-2xx), center the roll joint
```

Code Walkthrough



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        }

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        if(panIdx==-1U || tiltIdx==-1U)
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        float tilt=state->outputs[tiltIdx]-vert*CameraVertFOV/6;
        float pan=state->outputs[panIdx]-horiz*CameraHorizFOV/6;

        // now request access to the headpointer we added in doStart and set the joint angles
        MMAccessor<HeadPointerMC> headpointer(headpointer_id);
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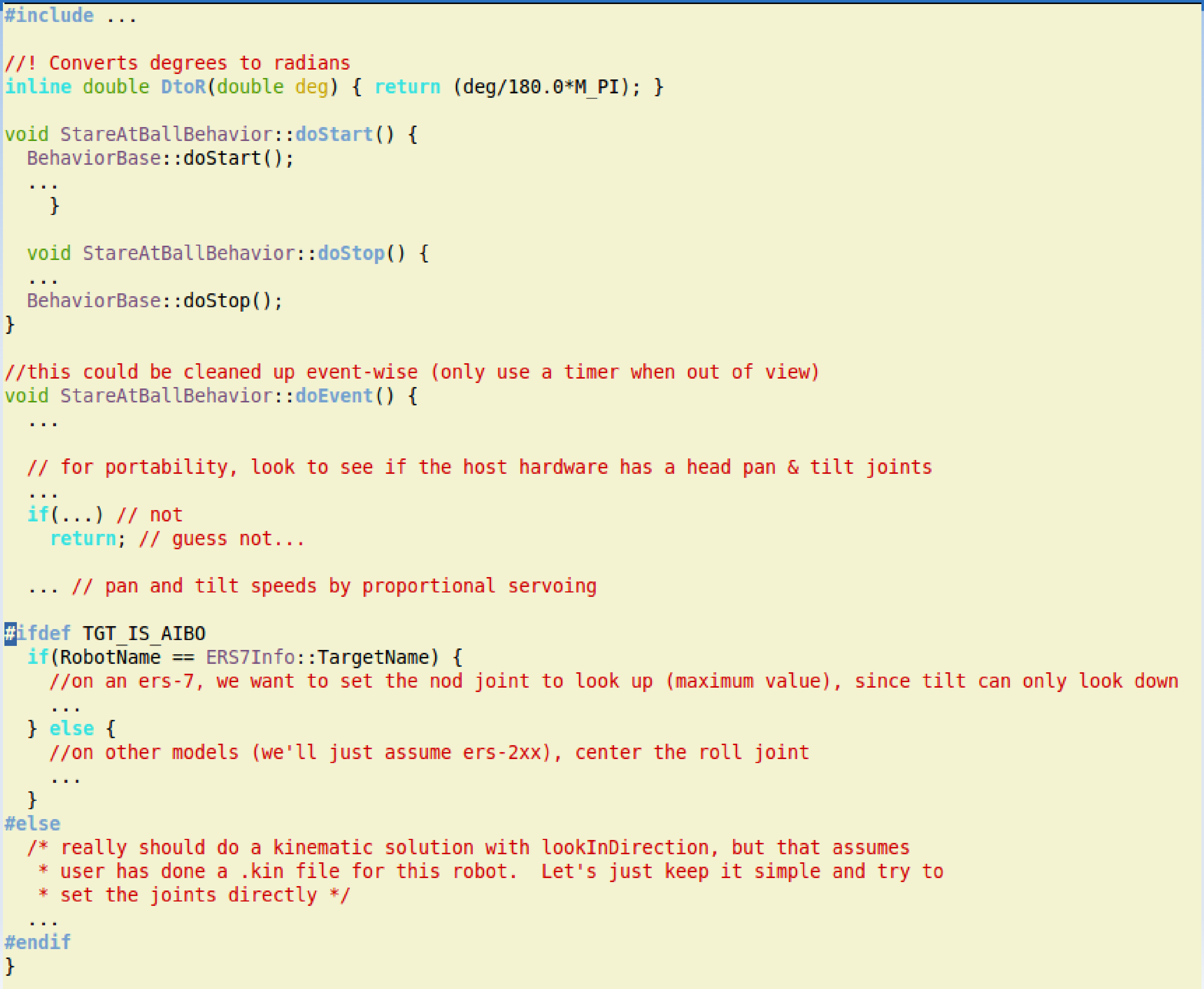
        if(RobotName == ERS7Info::TargetName) {
                //on an ers-7, we want to set the nod joint to look up (maximum value), since tilt can only look down
                headpointer->setJoints(tilt,pan,outputRanges[HeadOffset+NodOffset][MaxRange]);
        } else {
                //on other models (we'll just assume ers-2xx), center the roll joint
                headpointer->setJoints(tilt,pan,0);
        }
#else
        /* really should do a kinematic solution with lookInDirection, but that assumes
         * user has done a .kin file for this robot.  Let's just keep it simple and try to
         * set the joints directly */
        if(NumHeadJoints>2)
                tilt/=2; // we're going to replicate the tilt parameter in the next call, so divide by 2
        headpointer->setJoints(tilt,pan,tilt);
#endif
}
```

Code Walkthrough



```
#include ...

//! Converts degrees to radians
inline double DtoR(double deg) { return (deg/180.0*M_PI); }

void StareAtBallBehavior::doStart() {
  BehaviorBase::doStart();
  ...
    }

  void StareAtBallBehavior::doStop() {
  ...
  BehaviorBase::doStop();
}

//this could be cleaned up event-wise (only use a timer when out of view)
void StareAtBallBehavior::doEvent() {
  ...

  // for portability, look to see if the host hardware has a head pan & tilt joints
  ...
  if(...) // not
    return; // guess not...

  ... // pan and tilt speeds by proportional servoing

#ifdef TGT_IS_AIBO
  if(RobotName == ERS7Info::TargetName) {
    //on an ers-7, we want to set the nod joint to look up (maximum value), since tilt can only look down
    ...
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