AIBO Robot Research
CSE Team Final Presentation

Raimi Ishikawa
Mike Senchyshyn
Ryan Trinkle
Overview

- Purpose
- Project ideas
- Project proposal
- Gait research
- Parameterization
- Simulation
- Final gait
- Waveform editor
- Obstacles
- Future improvements
Purpose

- Research aspect of AIBO soccer
- Future RPI RoboCup team
  - Useful skill
  - Competitive edge
  - New strategy
Project Ideas

- Recover from fall
- Optimize shooting
- Pass, receive, pass back
Project Proposal

- Develop upright gait
- Usefulness in AIBO soccer
  - Run to ball
  - Take control of ball
  - Crouch and dribble
- Strategy not seen in AIBO soccer
Project Proposal

- **Programming language: OPEN-R**
  - Easy to create new modules
  - Excellent for low-level robotic research

- **Genetic computing**
  - Ideal for optimization
  - Feasibility?
Gait Research

- Sony’s gaits
- Existing gaits
- Wildlife gaits

[Image of a robot with the text "ERS-7 AIBO Entertainment Robot Expression"]
Sony’s Gaits

- NASA group
  - Evolutionary algorithms
  - Sony ERS-110 prototype
  - Evolved dynamic gait
    - Used on first consumer version of AIBO

- ERS-7 (Video)
  - Implements single gait
  - Very unstable
Existing Gaits

- Fastest known gait: 350mm/s
  - CMU website (June 2004)
  - Learned through genetic algorithm
  - Crouching gait

- Second fastest gait: 291mm/s
  - UT Austin website (November 2003)
  - Learned through genetic algorithm
  - Crouching gait
Existing Gaits

- Tekkotsu gait: 180mm/s
  - Tekkotsu Monitor
  - Crouching gait
Wildlife Gaits

- **Walk**
  - 4 beats
  - Legs move in diagonals
    - Front legs slightly precede rear legs
  - Static at start of step
  - Weight shifted forward while stepping

THE WALK—In the nine diagrams, the Fox Terrier demonstrates the complete sequence of a full stride of the walk. The left front starts the action. Positions 1 and 2 show the right diagonal; 3, right diagonal and left front; 4, the left lateral; 5 and 6, the left diagonal; 7, the left diagonal and right front; 8, the right lateral; and 9 takes us back to the start.
Wildlife Gaits

- **Trot**
  - 2 beats
  - Diagonals
  - Longer strides than walk
  - Dynamic

- **Pace**
  - 2 beats
  - Lateral
  - Dynamic

THE TROT—This German Shepherd in positions 1 and 3 shows the right and left diagonal, the two supports of the trot. Positions 2 and 4 show suspension which follows each diagonal in the “flying trot” which is rarely seen unless the dog is specifically bred for it. For the long stride as shown the dog must have excess body length over height to avoid the front and back leg hitting. THE PACE—Positions 5 and 6 show the right and left lateral of the pace, which is a fatigue gait and has never been highly developed in dogs. It must offer a restful change for dogs resorting to it after a hard day’s work.
Parameterization

- Laboratory of Electrical and Computer Engineering gait
  - Sinusoid movement of all joint angles
    - Simplest walk sequence

- Tekkotsu gait
  - Graphed maximum and minimum joint angles
    - Used as new starting point
Sinusoid Limitations

- Slightly extend front legs
  - Push into ground → walk backwards
- Fully extend front legs
  - Tiptoes → limp
- Could not implement upright gait
- Further developed crouched gait
Simulation: M-Edit

- Motions made up of key frames
  - Can create key frames in M-Edit
  - C++ program created to save time
- Key frames linked together and motions smoothed out
- Motions exported
Simulation: M-Edit
Simulation

- **R-Tool**
  - Converts motions
  - Creates configuration file

- **R-CODE**
  - Scripting Language
  - Copy files directly to memory stick
  - Copy R-Tool files
Final Gait

- Sinusoid gait: 360mm/s
- Crouched gait
- Diagonal legs 180° out of phase
- Left rear shoulder amplitude decreased
  - Compensates for turning right
  - Not ideal
- Exact joint angles unknown
Final Gait

Front leg joints
Final Gait

- Rear leg joints

**Graphs:**
- Left Rear Shoulder 1
- Right Rear Shoulder 1
- Left Rear Shoulder 2
- Right Rear Shoulder 2
- Left Rear Elbow
- Right Rear Elbow

Each graph shows the joint angle over a range of values from $-\pi \leq \theta \leq \pi$. The angles are measured in degrees for Left Rear Elbow and Right Rear Elbow.
Obstacles

- Installation
  - Cygwin
  - SDK
- OPEN-R
  - Lack of documentation and support
  - Unfamiliar architecture
- Asymmetrical joint response
- Time restrictions
Future Improvements

- Determine actual joint response
- Move towards closed-loop approach
- Real-time gait adjustment
- More complex parameterization
  - Development of standing gait
References

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