Learning Hierarchical Operators by Observation

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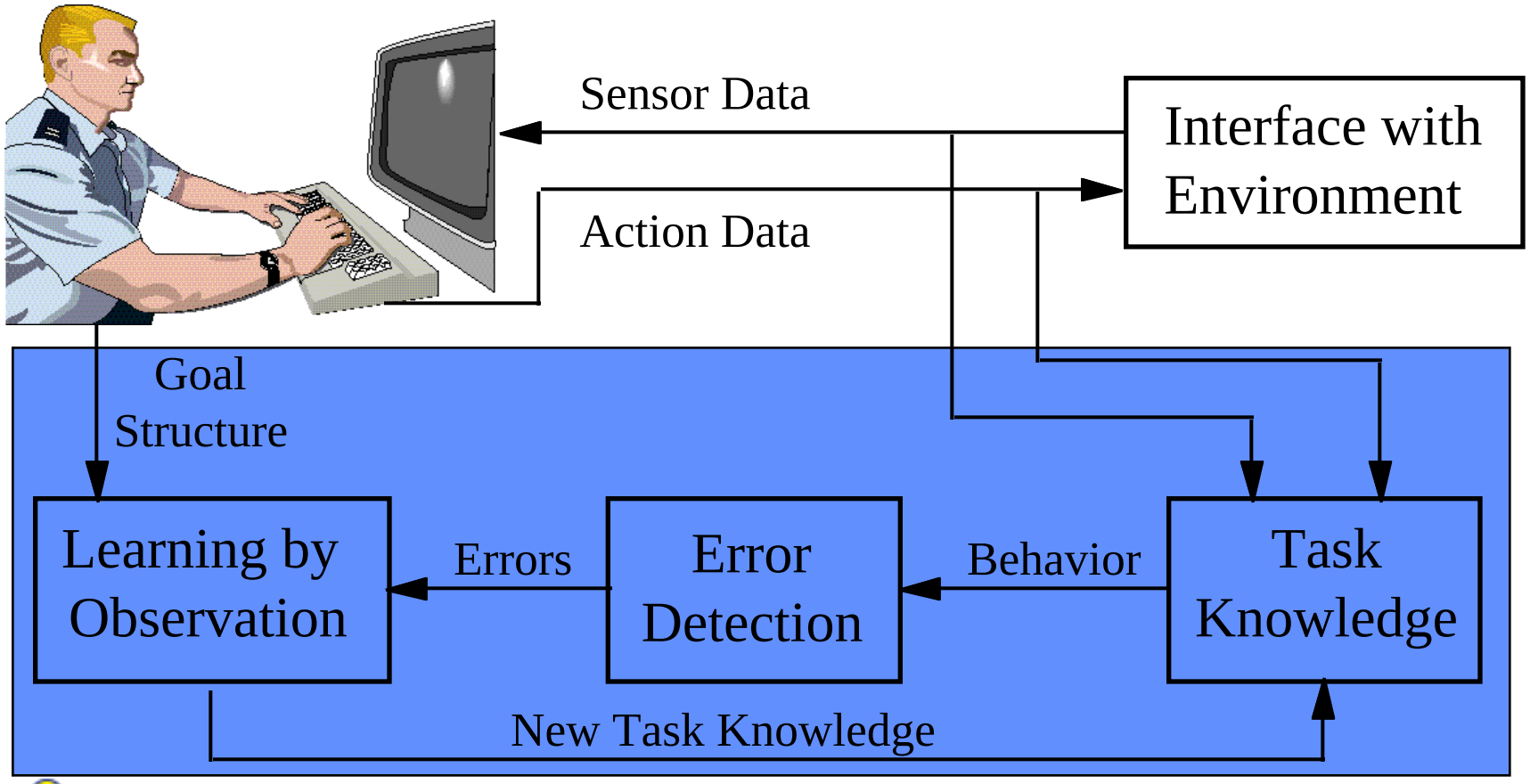
Soar Workshop XVII
June, 1997

Learning by Observation



Problem Statement

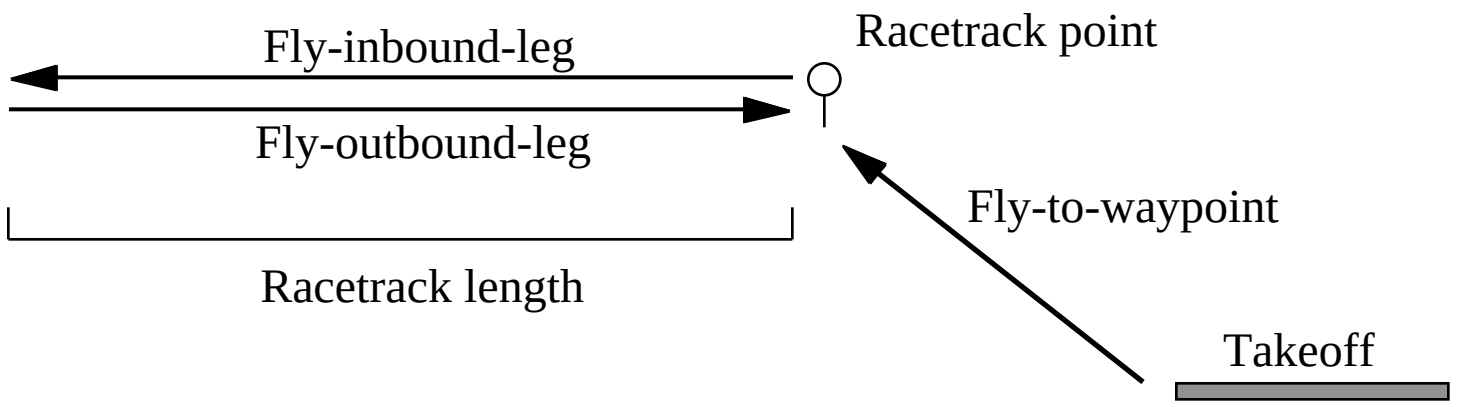
- Given
  - access to sensor data from the environment
  - access to action data from the expert
  - limited goal structure
  - available initial knowledge
- Learn
  - to perform as the expert would
  - in observed and unobserved situations

What needs to be learned

- Goal Operators: Hierarchy
  - Proposal Features
  - Parameter
  - Termination Features
  - Sub-operators
- Action Operators: Bottom level
  - Proposal Features
  - Parameters
  - Application
  - Termination Features
- Search Control

Example Domain

- Takeoff and Racetrack operators in TacAir-Soar
- Racetrack has three sub-operators & 1 parameter
  - Fly-to-waypoint, Fly-outbound-leg, Fly-inbound-leg
  - Racetrack point, Racetrack length



Error Detection

Expert	Task Knowledge	What is Learned
Start Takeoff	SNC	Learn Proposal Feature Learn Parameter (if possible)
Start Racetrack	Continue Takeoff	Learn Termination Feature Learn Proposal Feature
Start Inbound-leg	Start Outbound-leg	Learn Search Control Learn Proposal Feature
Set desired-speed	Wait	Learn Proposal Feature Learn Parameter Learn Application
Remove desired-speed	Leave desired-speed	Learn Termination Feature
Set desired-heading 90	Set desired-heading 0	Learn Parameter for Action Operator Learn Parameter for Super Goal

Incremental Learning

- Task Knowledge is added incrementally
  - Pass 1: Learn proposal features for Takeoff, Racetrack
  - Pass 2: Learn termination feature for Takeoff
    Learn proposal features for Fly-to-waypoint...
  - Pass 3: Learn termination features for Fly-to-waypoint...
- Features are improved incrementally
  - SCA: general to specific
  - Specific to general
  - Some combination of the two
- Parameters are improved incrementally
  - Better able to induce relationships with more examples

Early Results: Features Learned

- Propose Takeoff
  - 60+ conditions
  - Only matched during first decision cycle
- Terminate Takeoff (Propose Racetrack)
  - 3 conditions (speed, heading, altitude achieved)
  - Equivalent to the ^active *yes* feature is Micro-TAS
- Propose Fly-to-waypoint
  - 4 conditions (3 above and Racetrack super-operator)
- Terminate Fly-to-waypoint (Propose Fly-inbound-leg)
  - 2 conditions (waypoint.range.round & .value = 2969)
  - Equivalent to ^achieved-racetrack *yes*

Nuggets and Coal

- Nuggets
  - Potential for rapid development of agent knowledge
    - With variation in tactics, strategy and behavior
  - Builds in previous Soar research
    - Observation naturally compliments Instruction (Instructo-Soar)
    - Will use some form of general to specific induction (SCA)
    - Also IMPROV and SPLICE
- Coal
  - Preliminary results only
  - Still many fuzzy areas
    - Feature Improvement
    - Parameter Learning