

Rapid Model Building using Diagrams and Examples

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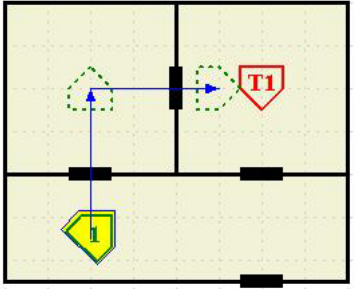


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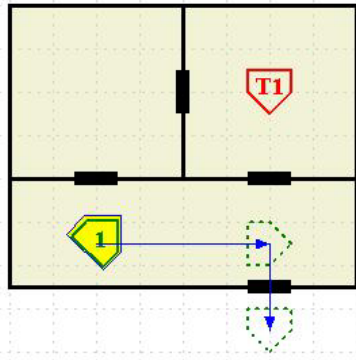
Start Date: January 1, 2003

Why Building Models is Hard

Desired Behavior

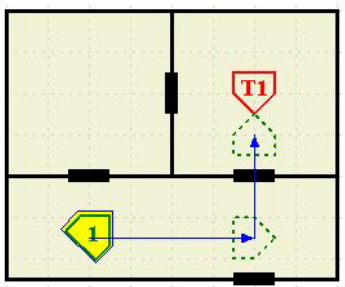


Actual Behavior



Errors and unvalidated behavior

Intended Behavior



Rules produce the behavior

- A -> B
- C -> D
- E, J -> F
- G, A, C -> H
- E, G -> I
- J, K -> L

Rules

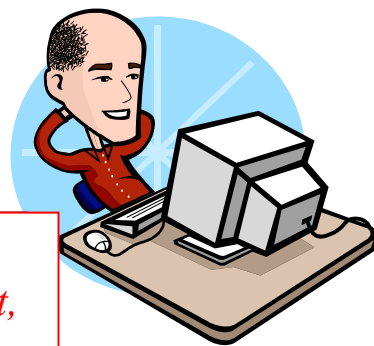


SME

Slow, Difficult, Error prone



Slow, Difficult, Error prone

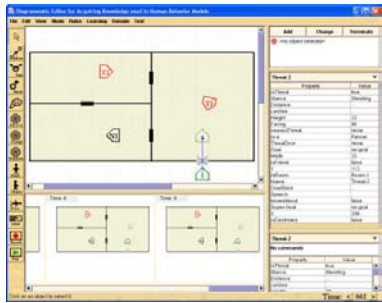


KE

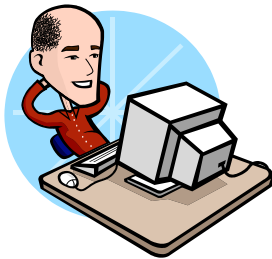
Slow, Difficult, Error prone

Diagram-based Example-driven Development Tool

Define behavior with diagram-based examples

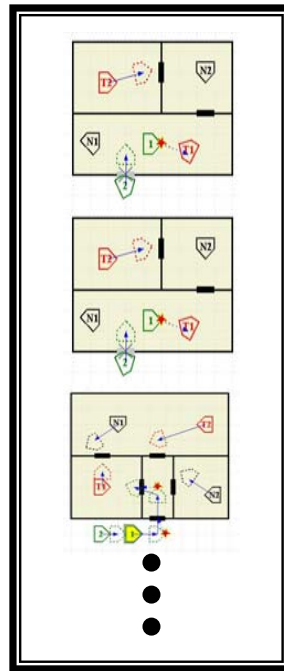


SME

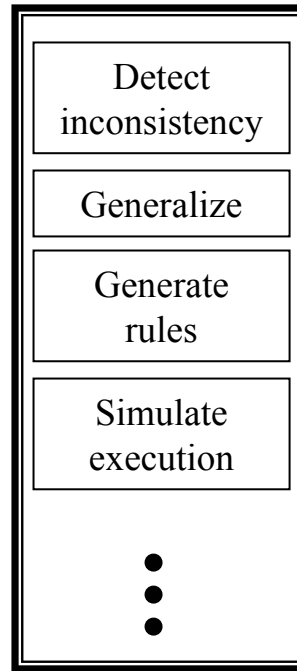


KE

Library of validated behavior examples



Analysis & generation tools



Executable Code

```
A -> B
C -> D
E, J -> F
G, A, C -> H
E, G -> I
J, K -> L
```



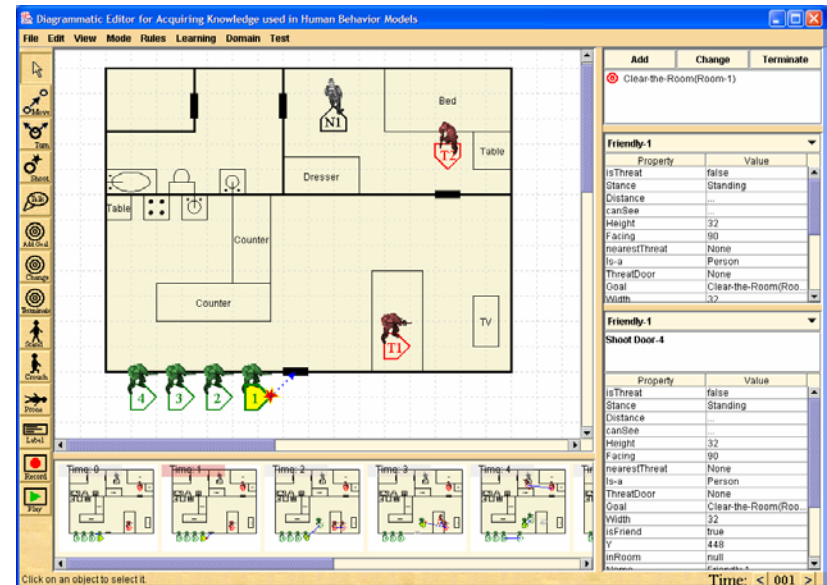
Simulation Environment



Tool demo

HBM Development Phases:

1. SME defines scenario
2. SME defines correct behavior
3. SME+KE indicate why behavior is chosen
4. Rules generated and automatically



Demo Screenshots: Layout Rooms

Diagrammatic Editor for Acquiring Knowledge used in Human Behavior Models

File Edit View Mode Rules Learning Domain Test

Click on an object to select it. Drag it to move it.

Property	Value
Distance	...
Width	32
Height	32
Facing	180
Y	176
Is-a	Furniture
Name	Sink-1
Furniture-Is-a	Sink
X	240
isDestroyed	false

Property	Value
Distance	...
Width	32
Height	32
Facing	180
Y	176
Is-a	Furniture
Name	Sink-1
Furniture-Is-a	Sink
X	240
isDestroyed	false

Demo Screenshots: Populate Rooms

Diagrammatic Editor for Acquiring Knowledge used in Human Behavior Models

File Edit View Mode Rules Learning Domain Test

The screenshot displays a software interface for creating a room layout. The main workspace shows a floor plan with several rooms and objects. A vertical toolbar on the left contains icons for Room, Door, N1, T1, N1, Sofa, TV, Counter, Bed, Dresser, Table, Toilet, Sink, and Cooker. At the bottom of the workspace, there are four green arrows labeled 1, 2, 3, and 4, indicating a sequence of actions. The right-hand panel contains a control area with 'Add', 'Change', and 'Terminate' buttons, and a status message '<no object selected>'. Below this are two property tables for an object named 'Friendly-1'.

Control Panel:

Add	Change	Terminate
<no object selected>		

Property Table 1 (Friendly-1):

Property	Value
width	32
isFriend	true
Y	448
inRoom	null
Name	Friendly-1
GoalStack	...
Speech	...
Super-Goal	no-goal
knowsAbout	true
isDestroyed	false
X	256

Property Table 2 (Friendly-1):

Property	Value
isThreat	false
Stance	Standing
Distance	...
canSee	...
Height	32
Facing	90
nearestThreat	None
Is-a	Person
ThreatDoor	None
Goal	no-goal
Width	32
isFriend	true
Y	448
inRoom	null
Name	Friendly-1

Click on an object to select it. Drag it to move it.



Demo Screenshots: Define Scenario

Diagrammatic Editor for Acquiring Knowledge used in Human Behavior Models

File Edit View Mode Rules Learning Domain Test

Click on an object to select it.

Add	Change	Terminate
Clear-the-Room(Room-1)		

Friendly-1	
Property	Value
isThreat	false
Stance	Standing
Distance	...
canSee	...
Height	32
Facing	90
nearestThreat	None
Is-a	Person
ThreatDoor	None
Goal	Clear-the-Room(Roo...
Width	32

Friendly-1	
Shoot Door-4	
Property	Value
isThreat	false
Stance	Standing
Distance	...
canSee	...
Height	32
Facing	90
nearestThreat	None
Is-a	Person
ThreatDoor	None
Goal	Clear-the-Room(Roo...
Width	32
isFriend	true
Y	448
inRoom	null
Name	Friendly-1

Time: < 001 >

Demo Screenshots: Define Behavior

Diagrammatic Editor for Acquiring Knowledge used in Human Behavior Models

File Edit View Mode Rules Learning Domain Test

Explain

Click on an object to select it.

Time: < 001 >

Property	Value
Distance	...
Width	32
Height	10
Y	416
Is-a	Door
Name	Door-4
X	304
isDestroyed	false

Property	Value
Distance	...
canSee	...
Height	32
Facing	90
nearestThreat	None
Is-a	Person
ThreatDoor	None
Goal	Clear-the-Room(Roo...
Width	32
isFriend	true
Y	448
inRoom	null
Name	Friendly-1
GoalStack	...

Demo Screenshots: Generate Rules

Diagrammatic Editor for Acquiring Knowledge used in Human Behavior Models

File Edit View Mode Rules Learning Domain Test

Guess Features for Commands

Generate Rule list

Load Rule

View Rule

Execute

View Issues

Generate

Table

Rule: ProposalRule-1 (Source: Command-1)
 (<Room-1> = ^Is-a Room)
 (<Friendly-1> = ^Goal no-goal)
 (<Friendly-1> = ^inRoom null)

ChangeGoal Command (Actor: <Friendly-1>)
 (<Friendly-1> ^AddGoal Clear-the-Room((Room-1)))

Rule: ProposalRule-2 (Source: Command-2)
 (<Door-4> = ^IsDestroyed false)
 (<Door-4> = ^Is-a Door)
 (<Friendly-1> = ^Goal Clear-the-Room((Room-1)))

Shoot Command (Actor: <Friendly-1>)
 (<Door-4> ^IsDestroyed true)
 (<Friendly-1> ^Facing 56)

Rule: ProposalRule-3 (Source: Command-3)
 (<Friendly-1> = ^inRoom null)
 (<Friendly-1> = ^IsFriend true)
 (<Friendly-1> = ^IsThreat false)
 (<Friendly-1> = ^Is-a Person)
 (<Friendly-1> = ^Goal Clear-the-Room((Room-1)))

Move Command (Actor: <Friendly-1>)
 (<Friendly-1> ^X 336)
 (<Friendly-1> ^Y 368)
 (<Friendly-1> ^Facing 45)

Rule: ProposalRule-4 (Source: Command-5)
 (<Threat-1> = ^IsDestroyed false)
 (<Threat-1> = ^IsFriend false)
 (<Threat-1> = ^IsThreat true)
 (<Threat-1> = ^Is-a Person)
 (<Friendly-1> = ^IsFriend true)

Property	Value
...	...
32	10
416	Door
Door-4	304
...	false

Property	Value
chromometry	...
...	...
32	90
at	None
Person	None
None	Clear-the-Room(Roo...
32	true
448	448
InRoom	null
Name	Friendly-1
GoalStack	...

Click on an object to select it.

Time: < 001 >

Demo Screenshots: Detect Errors

Diagrammatic Editor for Acquiring Knowledge used in Human Behavior Models

File Edit View Mode Rules Learning Domain Test

Guess Features for Commands
Generate Rules
Load Rules from File
View Rules
 Execute Rules
View Issues

Current issues list

Current issues: 11

Issue	Time	Issue	Context
1	0	Variable [Room-1] could take multiple values - Room-1,Room-2,Room-3,Room-4. Randomly picking the first.	Firing rule ProposalRule-1 Creating command *Add Goal Clear-the-Room(Room-1)

Rule: ProposalRule-1 (Source: Command-1)
 (<Room-1> = ^!s-a Room)
 (<Friendly-1> = ^!Goal no-goal)
 (<Friendly-1> = ^!InRoom null)
 -->
 ChangeGoal Command (Actor: <Friendly-1>)
 (<Friendly-1> ^AddGoal Clear-the-Room((Room-1)))

Regenerate Rules < Previous Next >

Click on an object to select it. Time: < 000 >

Demo Screenshots: Simulate Behavior

Diagrammatic Editor for Acquiring Knowledge used in Human Behavior Models

File Edit View Mode Rules Learning Domain Test

Click on an object to select it.

Time: < 002 >

Property	Value
Distance	...
Width	32
Height	10
Y	416
Is-a	Door
Name	Door-4
X	304
isDestroyed	true

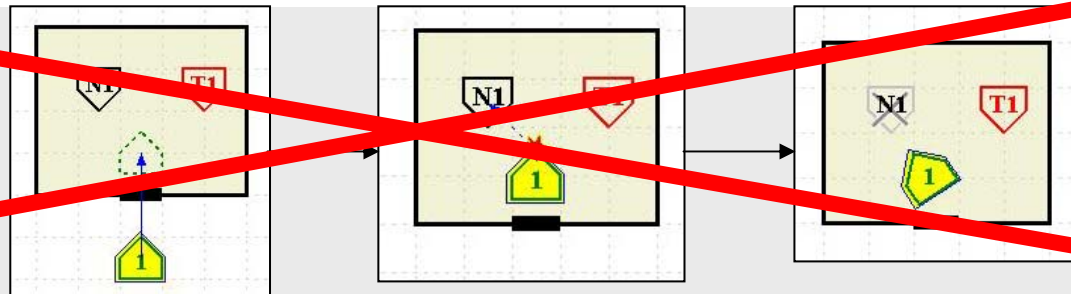
Property	Value
isThreat	false
Stance	Standing
Distance	...
canSee	...
Height	32
Facing	45
nearestThreat	Threat-1
Is-a	Person
ThreatDoor	None
Goal	Clear-the-Room(Roo...
Width	32
isFriend	true
Y	368
inRoom	Room-1

Improved HBM Development

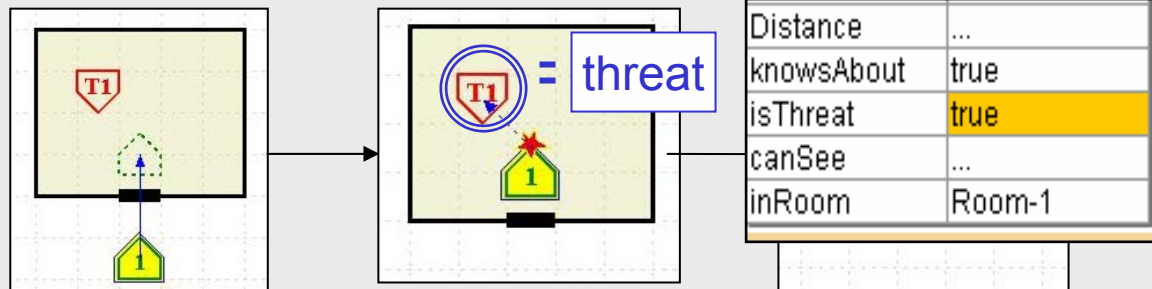
- Minimize HBM Development Cost
 - Extract maximal knowledge from examples
- Ensure Correctness of Behavior
 - Immediate verification on current example
 - *Consistency analysis across example library*
- Minimize HBM Maintenance Cost
 - Maintain validated examples, not code
 - Greatly decrease need for KE
- Minimize Cost of Tool Development & Use
 - Use same tool for multiple domains
 - *Use same tool for multiple target architectures*

Define General Tactics, not Scripted Behavior

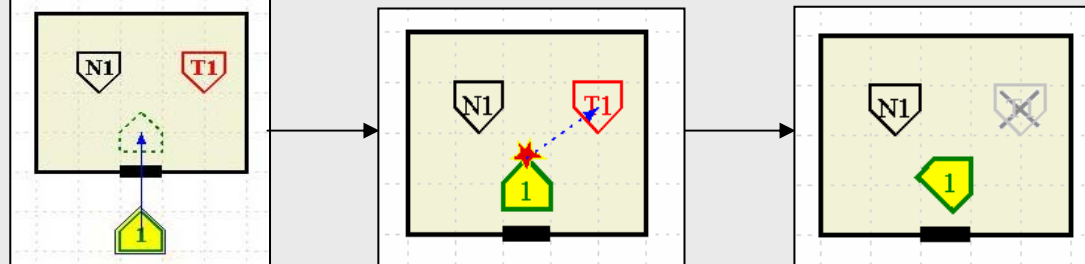
~~Incorrect
Scripted
Behavior~~



Original
Example



Correct
General
Behavior



User Controls the Generality of the Examples

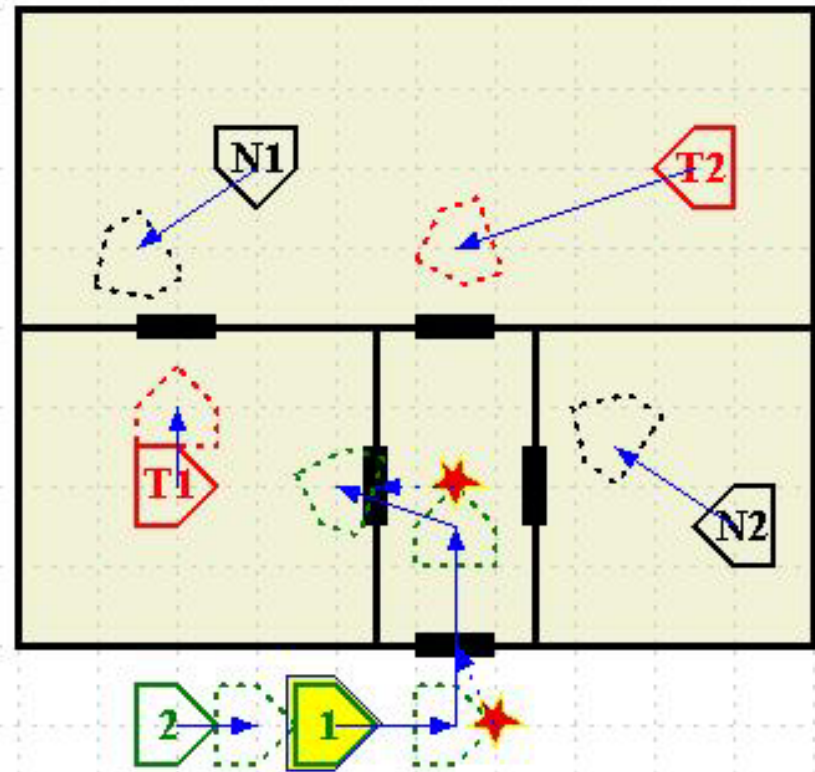
- Select few features
 - General rule
 - More coverage
 - But easier to introduce errors
- Select lots of features
 - Specific rule
 - Less coverage
 - But less chance of errors

Friendly-1	
Property	Value
canSee(Threat-1)	true
Distance(Threat-1)	Medium
Threat-1	
Property	Value
canSee	...
canSee(Friendly-1)	true
Distance	...
Distance(Friendly-1)	Medium
inRoom	Room-1
Is-a	Person
isDestroyed	false
isFriend	false
isThreat	true
nearestThreat	Friendly-1
Speech	
Stance	Standing

Learn Tactics for all Entities

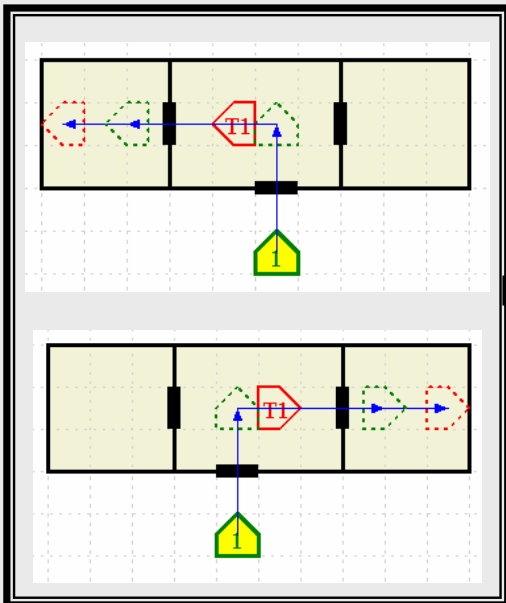
Specify tactics for many entities in single example

- Friendly forces
- Adversary forces
- Neutrals



Learn Behavior for Novel Situations

Library of validated behavior examples



Initial Rules

```
Threat-go [left]
→
Move [left]

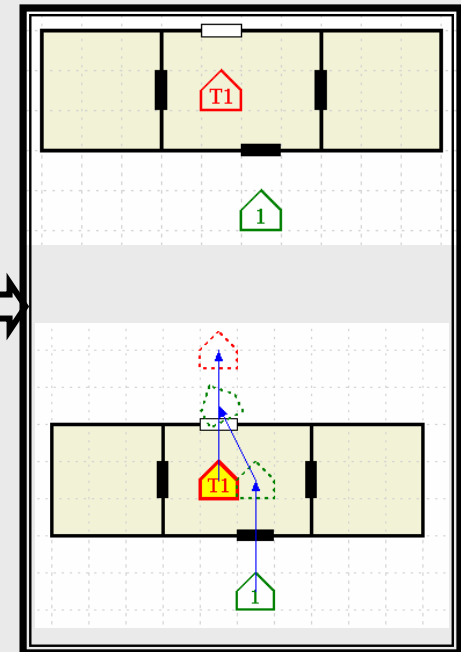
Threat-go [right]
→
Move [right]
```

Generalized Rules

```
Threat-go [x]
→
Move [x]
```

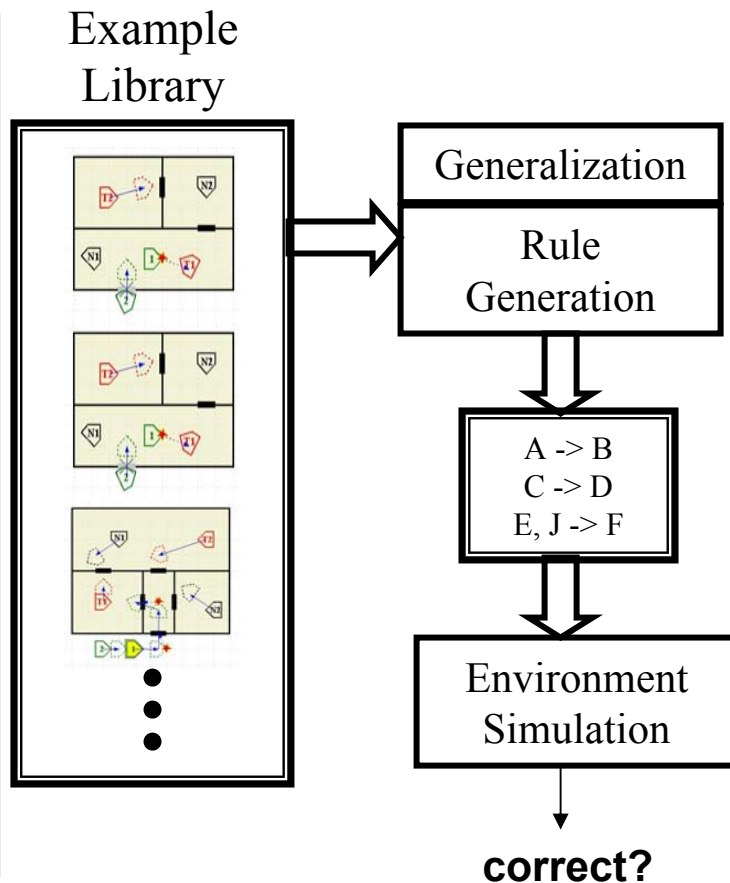
Learner

Correct Behavior in Novel Situation

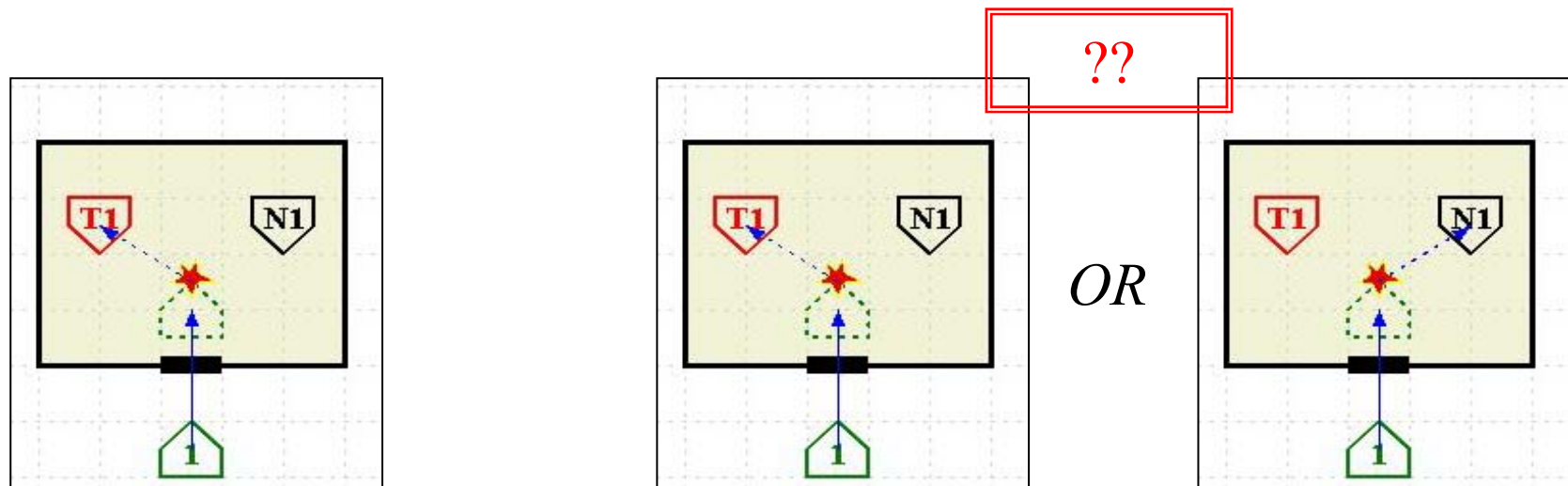


Compare to Desired Behavior Automatically

- Generate rules from example library
- Execute rules on example scenarios
- Detect when rule behavior \neq expert behavior
- Ensures correctness



Errors are Detected Immediately

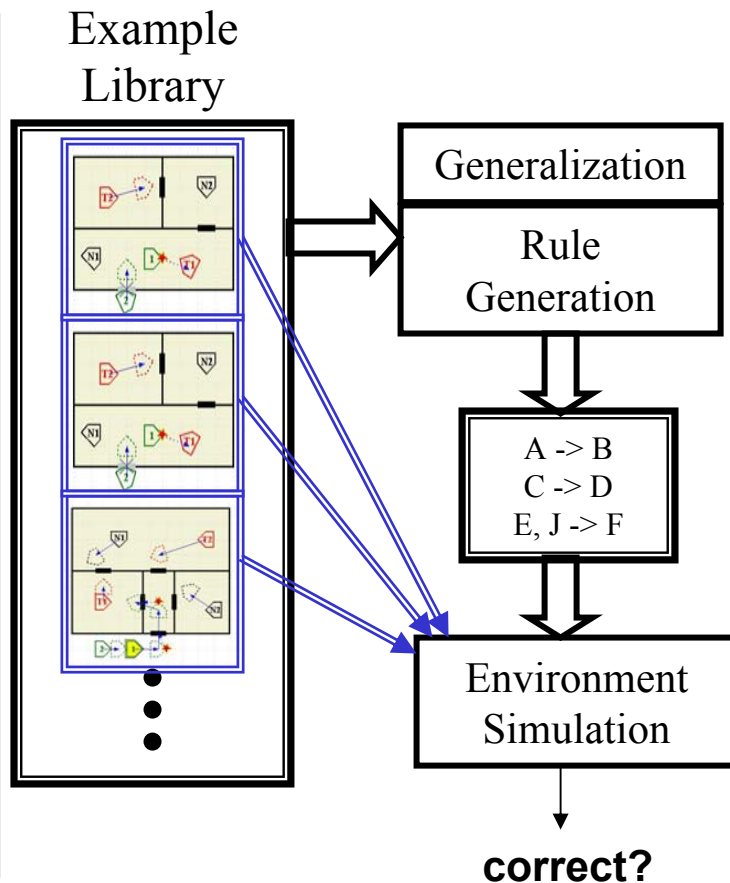


Specified behavior

- Detects if behavior could be interpreted two ways
- Tool detects this at design time – not run time

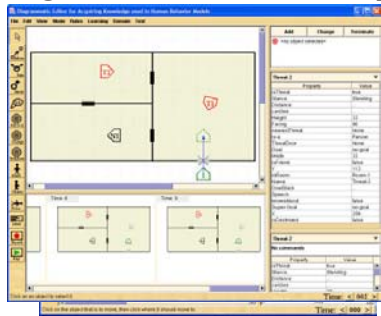
Detect Inconsistencies Across Examples

- Not limited to just testing within scenarios
- Test knowledge automatically across all defined scenarios
- With standard KA this is too expensive – usually not done at all.

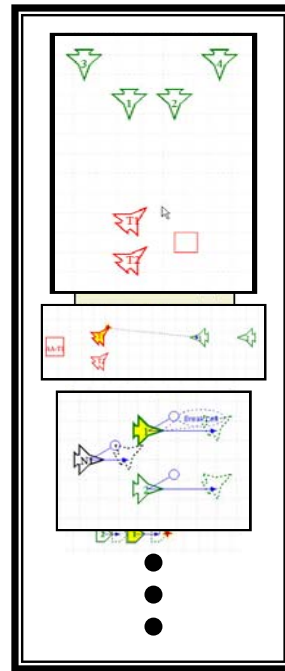


Use Tool in Multiple Domains

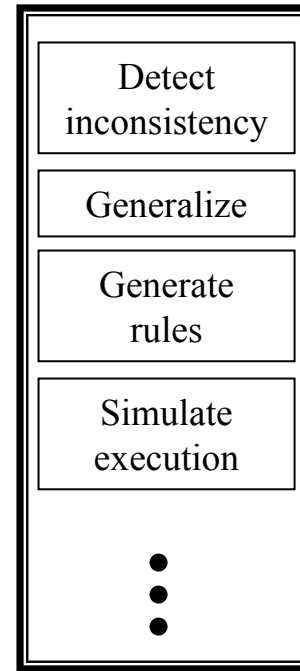
Define behavior with
diagram-based examples



Library of validated
behavior examples

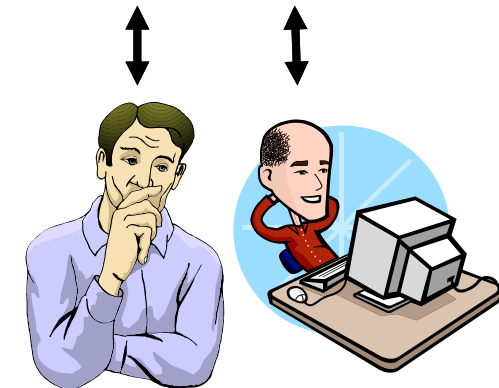


Analysis &
generation tools



Rules
(Soar)

```
A -> B
C -> D
E, J -> F
G, A, C -> H
E, G -> I
J, K -> L
```



SME

KE

Simulation
Environment

90% code base is domain independent



Use Same Tool for Air Domain

Diagrammatic Editor for Acquiring Knowledge used in Human Behavior Models

File Edit View Mode Rules Learning Domain Test

AA-T1

Move Turn Shoot Talk Add Goal Change Terminate Label Record Play

Time: 0 Time: 1 Time: 2 Time:

Click on the object that is to move, then click where it should move to.

Time: < 000 >

Add **Change** **Terminate**

<no goals>

+ Engage-Enemy-Plane(ThreatPlane-1)

FriendlyPlane-1

Property	Value
isThreat	false
Distance	...
Goal	no-goal
Width	48
Height	48
Facing	15
isFriend	true
Y	432
Name	FriendlyPlane-1
Is-a	Plane

FriendlyPlane-1

Add Goal Engage-Enemy-Plane(ThreatPlane-1)
Move (464,368)

Property	Value
isThreat	false
Distance	...
Goal	no-goal
Width	48
Height	48
Facing	15
isFriend	true
Y	432
Name	FriendlyPlane-1
Is-a	Plane
Speech	
GoalStack	...
Super-Goal	no-goal
Altitude	6000
isDestroyed	false
X	432

Planned Evaluation

- Build an agent in the MOUT domain and compare against current development efforts.



- Additional funding required to formally evaluate.

Nuggets

- Development Cost: 5x faster
 - 1-2 hours with tool = 1-2 days without
- Validation: 5x fewer errors
 - Eliminate errors during development
- Maintenance: 5x less effort
 - May eliminate need for KE
- Completely new opportunities for HBM use

Coal

- Still early days – mostly “potential”
- Extending the representation language (e.g. adding a new concept)
- Mapping between simulations and rules
- Interface doesn't make full use of diagrams and too hard for SMEs to use on their own
- Getting new tools adopted is always hard

The End

Diagrammatic Editor for Acquiring Knowledge used in Human Behavior Models

File Edit View Mode Rules Learning Domain Test

Explain

Click on an object to select it.

Property	Value
Distance	...
Width	32
Height	10
Y	416
Is-a	Door
Name	Door-4
X	304
isDestroyed	true

Property	Value
isThreat	false
Stance	Standing
Distance	...
canSee	...
Height	32
Facing	45
nearestThreat	Threat-1
Is-a	Person
ThreatDoor	None
Goal	Clear-the-Room(Roo...
Width	32
isFriend	true
Y	368
inRoom	Room-1
Name	Friendly-1

Time: < 002 >