



# Reasoning and Planning in ArmarX

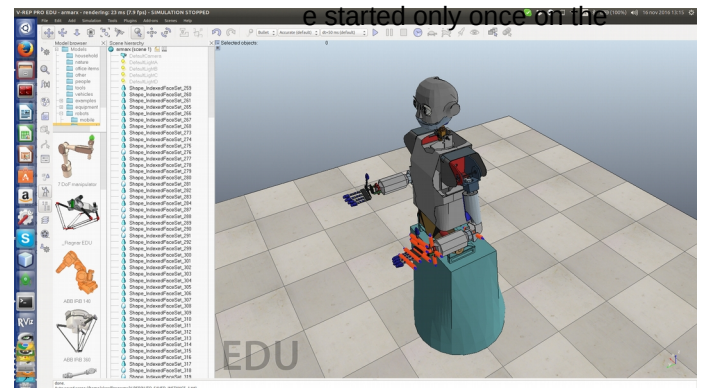
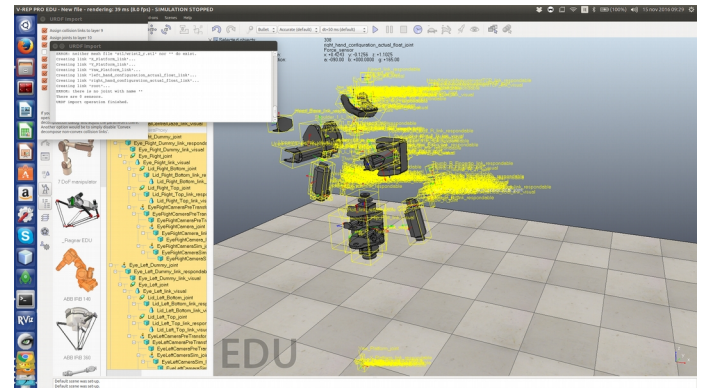
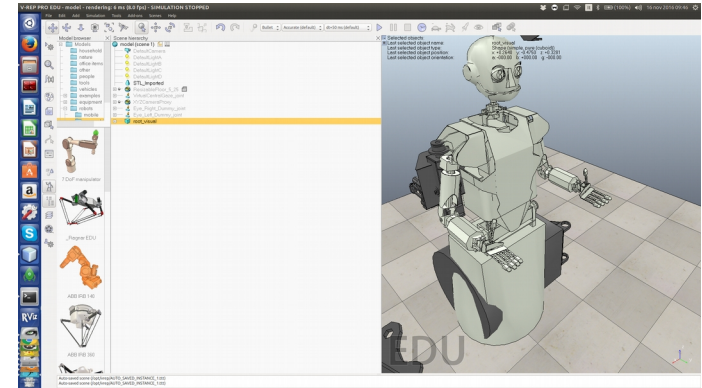
Mario Gianni, Fiora Pirri and Francesco Puja  
ALCOR Laboratory, DIAG, Sapienza University Of Rome



Integration Meeting – November 17, 2016 – Rome, Italy

# Outline

- Reasoning
  - Structures
  - Relations
- Levels of reasoning
  - Logical
  - Statistical
  - Temporal
- Learning
- Planning Library
- Execution



e started only once on the

# Reasoning in ArmarX

Features

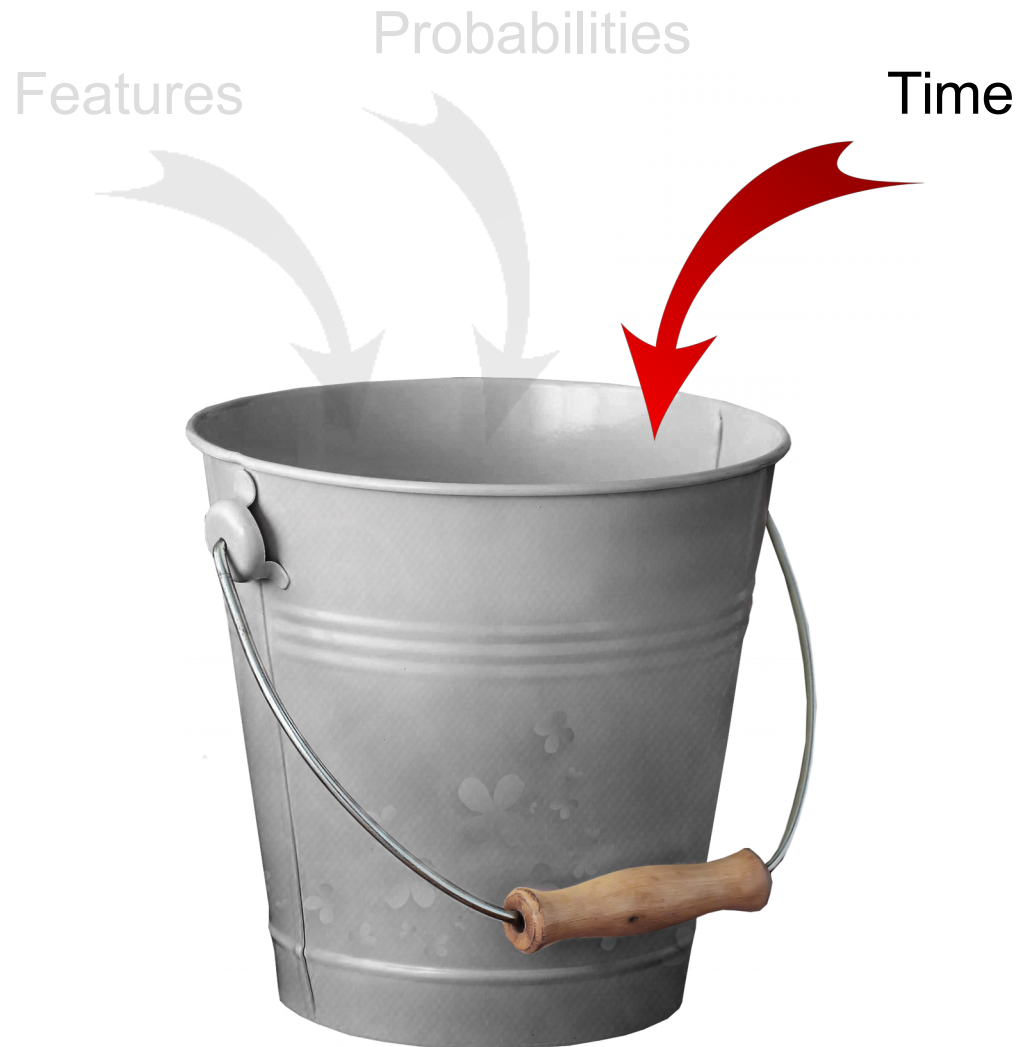


# Reasoning in ArmarX

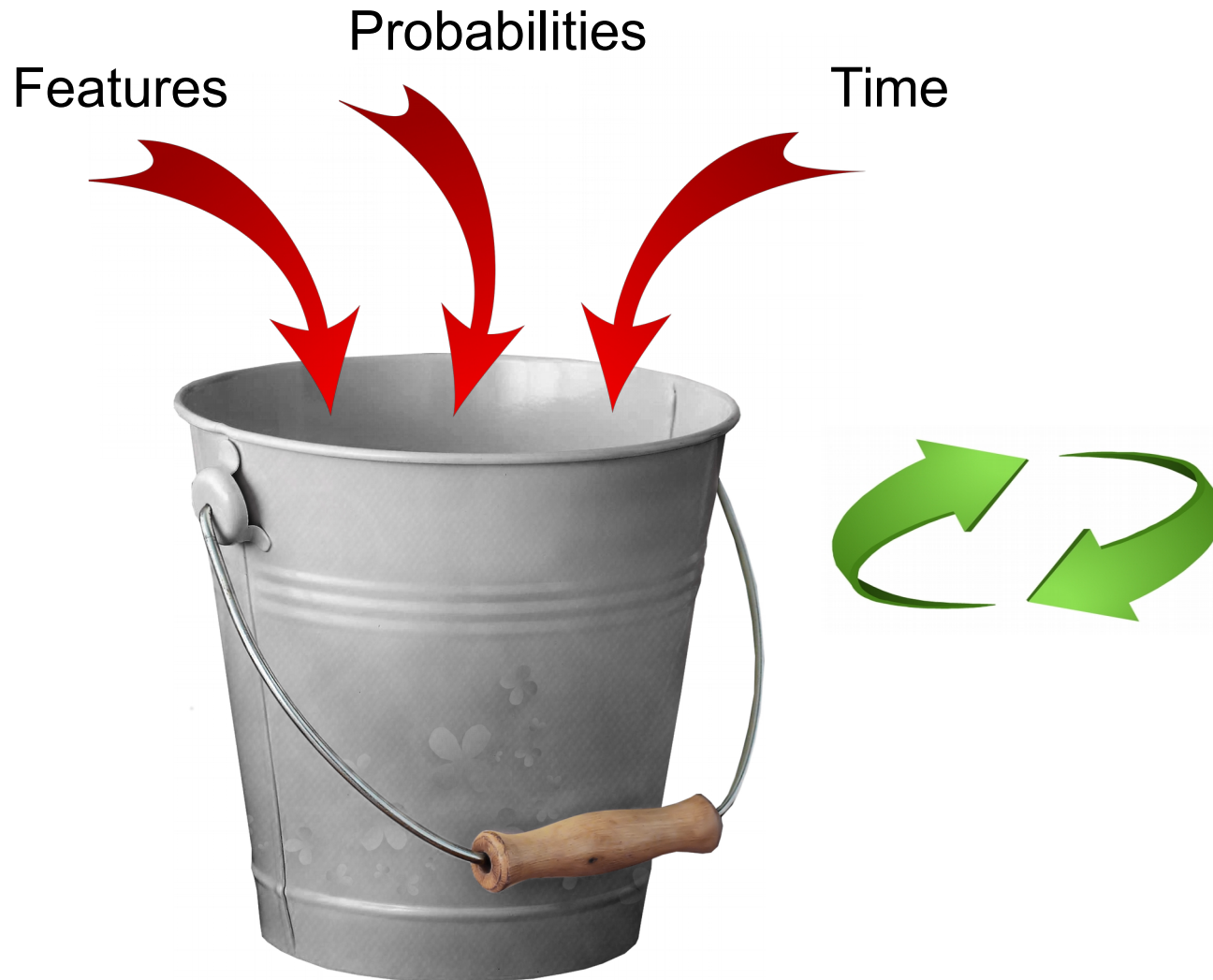




# Reasoning in ArmarX



# Reasoning in ArmarX



Representation

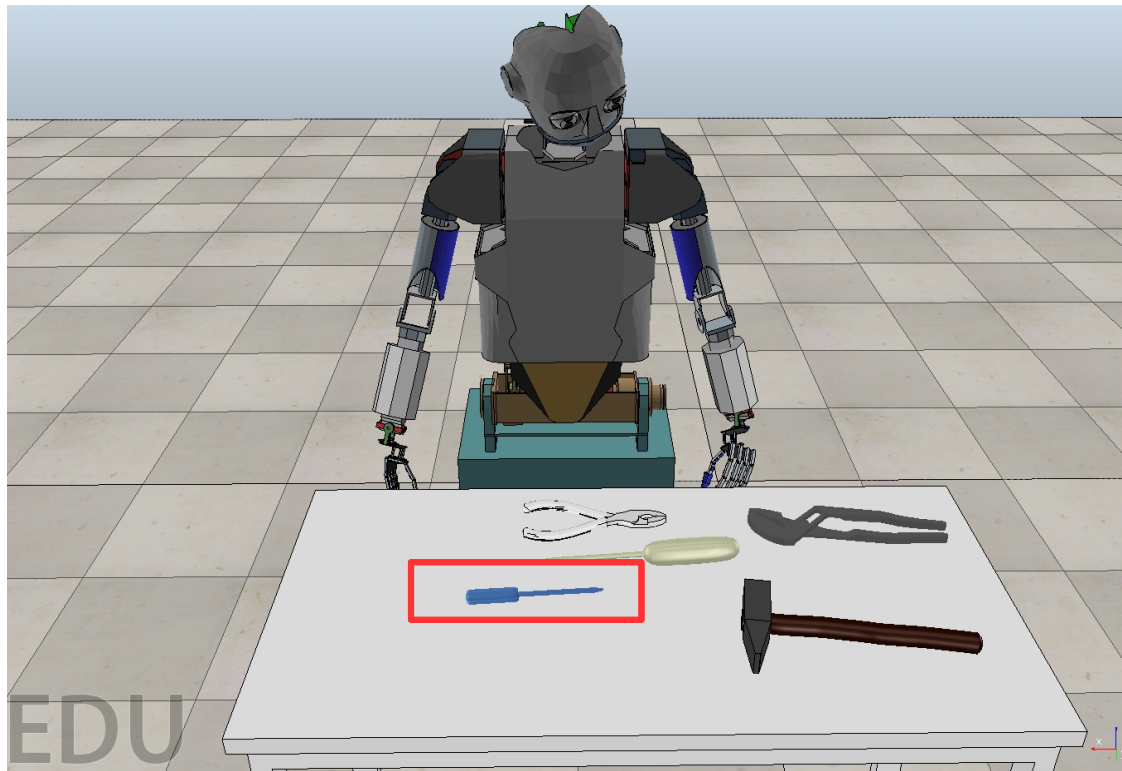
Association

Update

Consistency

# Structures

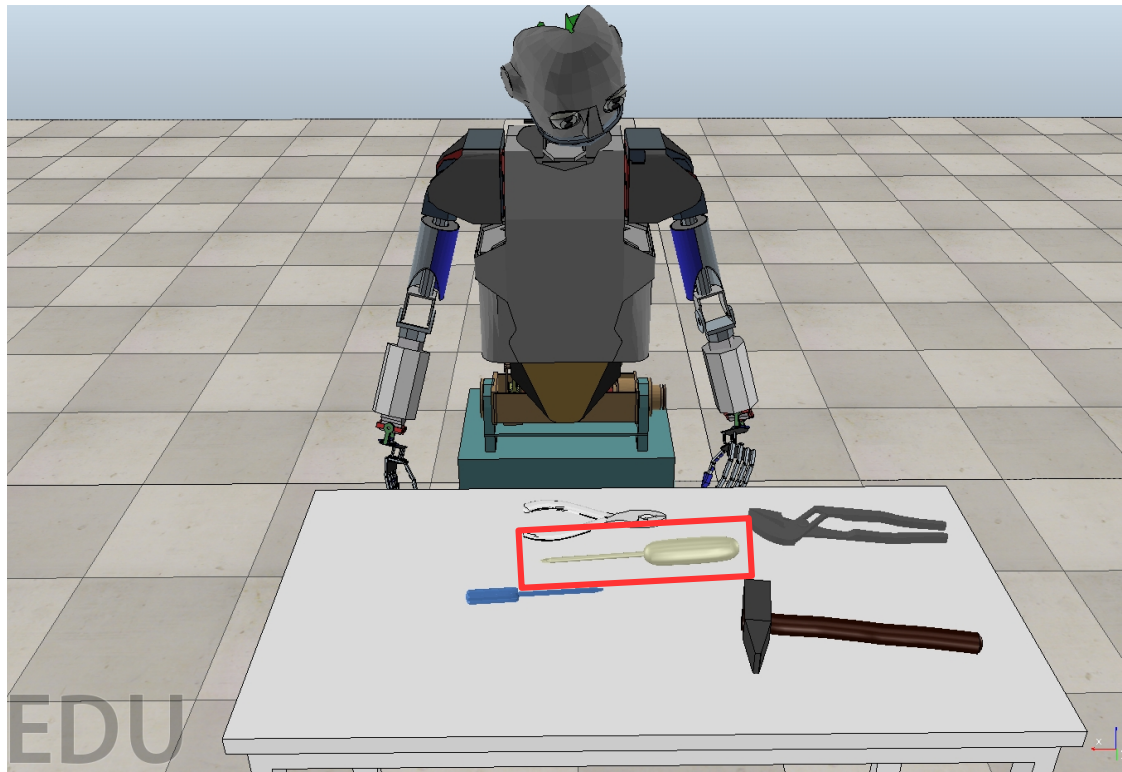
example



	Object
class	tool
type	screwdriver
id	00000001
color	blue
X	+5.7500e-01
y	+1.6750e+00
Z	+9.2000e-01
alpha	+9.0000e+01
beta	-8.6000e+01
gamma	+1.6234e+02
prob	0.25

# Structures

example



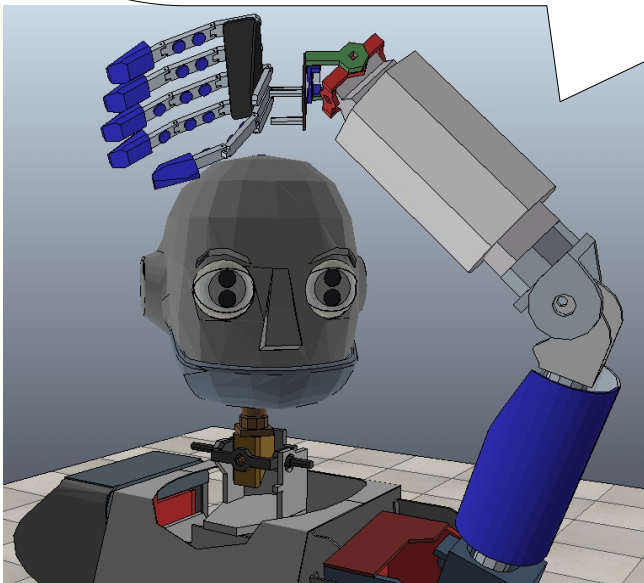
	Object
class	tool
type	screwdriver
id	00000002
color	Light-green
X	+4.0000e-01
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Z	+9.2000e-01
alpha	+3.6718e-05
beta	-8.6000e+01
gamma	+1.6234e+02
prob	0.98

EDU

# Structures

## Grounding

ん	わ	ら	や	ま	ば	な	た	さ	か	あ
N	WA	RA	YA	MA	HA	NA	TA	SA	KA	A
	ゐ	り		み	ひ	に	ち	し	き	い
	WI	RI		MI	HI	NI	CHI	SHI	KI	I
		る	ゆ	む	ふ	ぬ	つ	す	く	う
		RU	YU	MU	FU	NU	TSU	SU	KU	U
	ゑ	れ		め	へ	ね	て	せ	け	え
	WE	RE		ME	HE	NE	TE	SE	KE	E
	を	ろ	よ	も	ほ	の	と	そ	こ	お
	WO	RO	YO	MO	HO	NO	TO	SO	KO	O

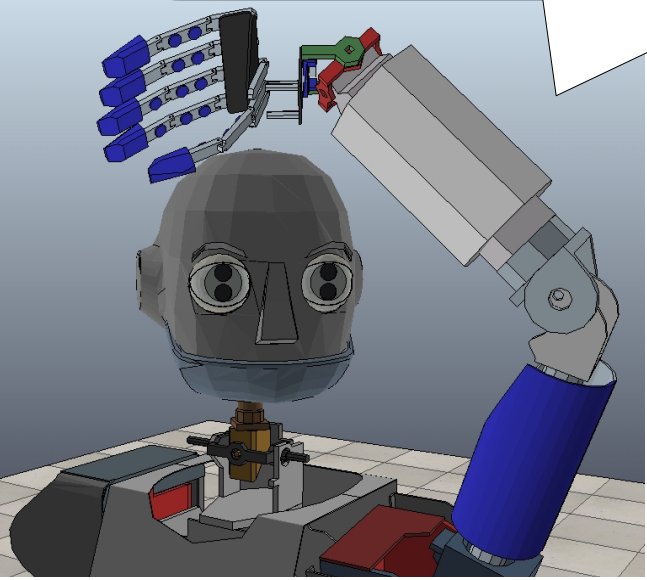


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alpha	+3.6718e-05
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gamma	+1.6234e+02
prob	0.98

# Structures

## Association

ん	わ	ら	や	ま	ば	な	た	さ	か	あ
N	WA	RA	YA	MA	HA	NA	TA	SA	KA	A
	ゐ	り		み	ひ	に	ち	し	き	い
	WI	RI		MI	HI	NI	CHI	SHI	KI	I
		る	ゆ	む	ふ	ぬ	つ	す	く	う
		RU	YU	MU	FU	NU	TSU	SU	KU	U
	ゑ	れ		め	へ	ね	て	せ	け	え
	WE	RE		ME	HE	NE	TE	SE	KE	E
	を	ろ	よ	も	ほ	の	と	そ	こ	お
	WO	RO	YO	MO	HO	NO	TO	SO	KO	O



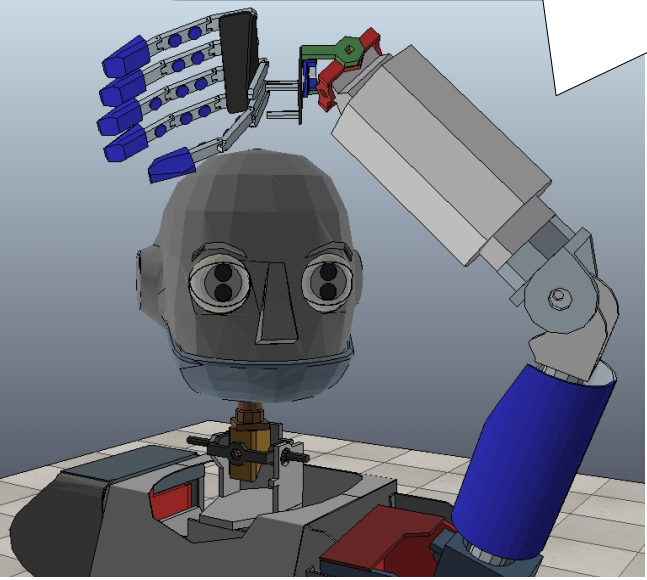
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type	screwdriver
id	00000002
color	Light-green
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# Structures

## Grounding

ん	わ	ら	や	ま	ば	な	た	さ	か	あ
N	WA	RA	YA	MA	HA	NA	TA	SA	KA	A
	ゐ	り		み	ひ	に	ち	し	き	い
	WI	RI		MI	HI	NI	CHI	SHI	KI	I
		る	ゆ	む	ふ	ぬ	つ	す	く	う
		RU	YU	MU	FU	NU	TSU	SU	KU	U
	ゑ	れ		め	へ	ね	て	せ	け	え
	WE	RE		ME	HE	NE	TE	SE	KE	E
	を	ろ	よ	も	ほ	の	と	そ	こ	お
	WO	RO	YO	MO	HO	NO	TO	SO	KO	O



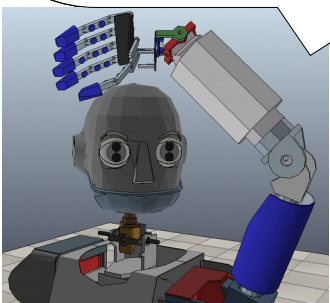
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type	screwdriver
id	00000002
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X	+4.0000e-01
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prob	0.98

# Structures

Time  $t_n$



	Object
class	tool
type	<b>screwdriver</b>
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color	blue
X	+5.7500e-01
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Z	+9.2000e-01
alpha	+9.0000e+01
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gamma	+1.6234e+02
prob	0.25

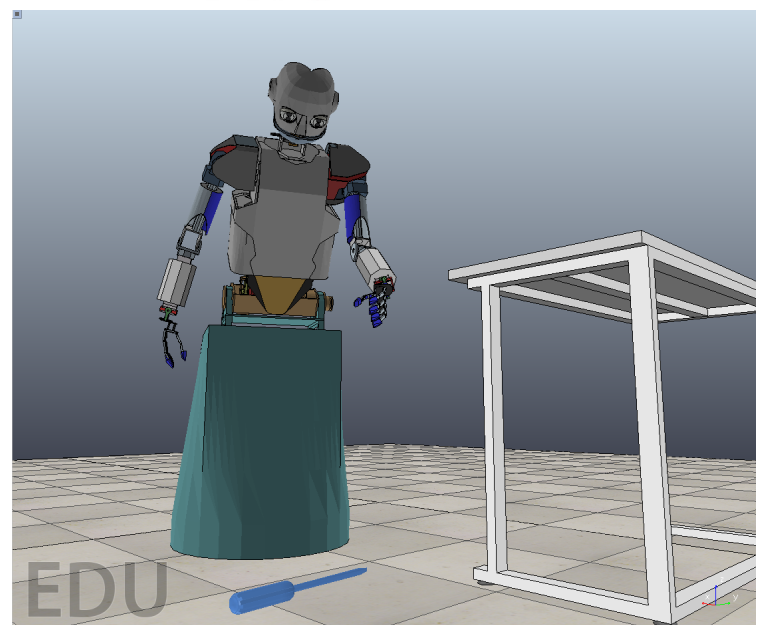
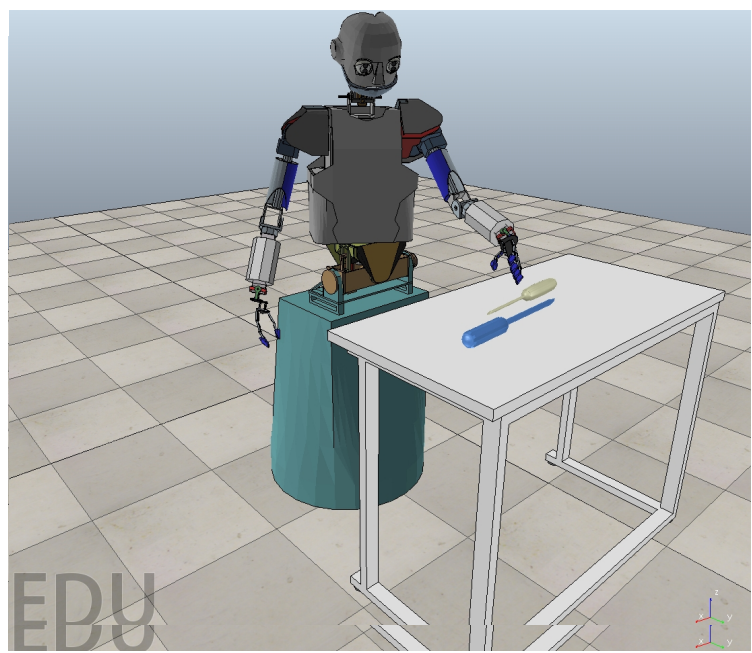
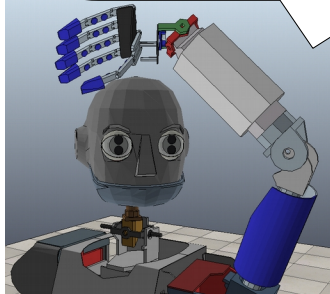


Time  $t_{n+1}$

Anchoring



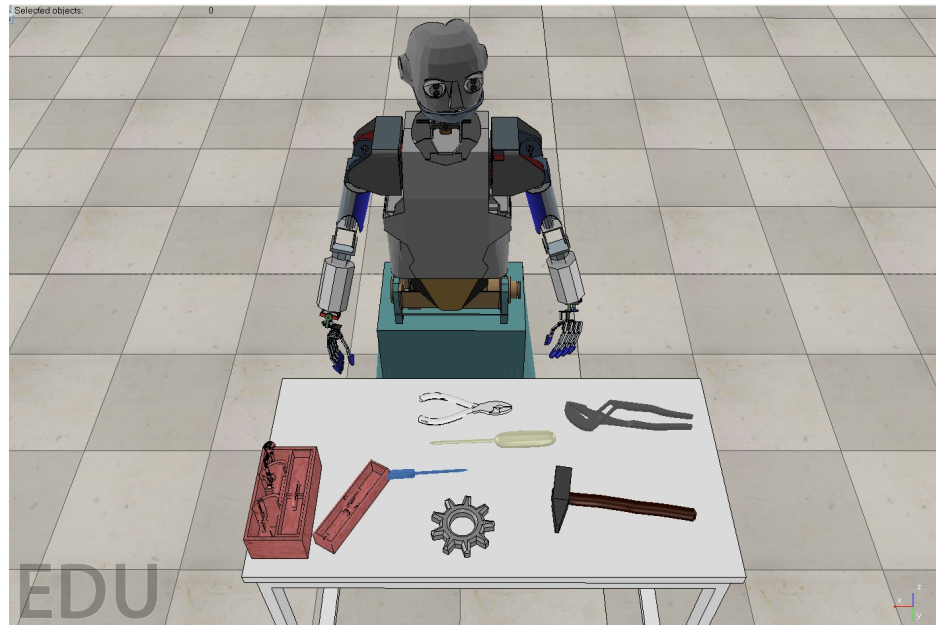
	Object
class	tool
type	<b>screwdriver</b>
id	00000001
color	blue
X	+5.7500e-01
y	+1.6750e+00
Z	+9.2000e-01
alpha	+9.0000e+01
beta	-8.6000e+01
gamma	+1.6234e+02
prob	0.25



# Structures

## Relations

	Object
class	tool
type	screwdriver
id	00000002
color	Light-green
X	+4.0000e-01
y	+1.5750e+00
Z	+9.2000e-01
alpha	+3.6718e-05
beta	-8.6000e+01
gamma	+1.6234e+02
prob	0.98

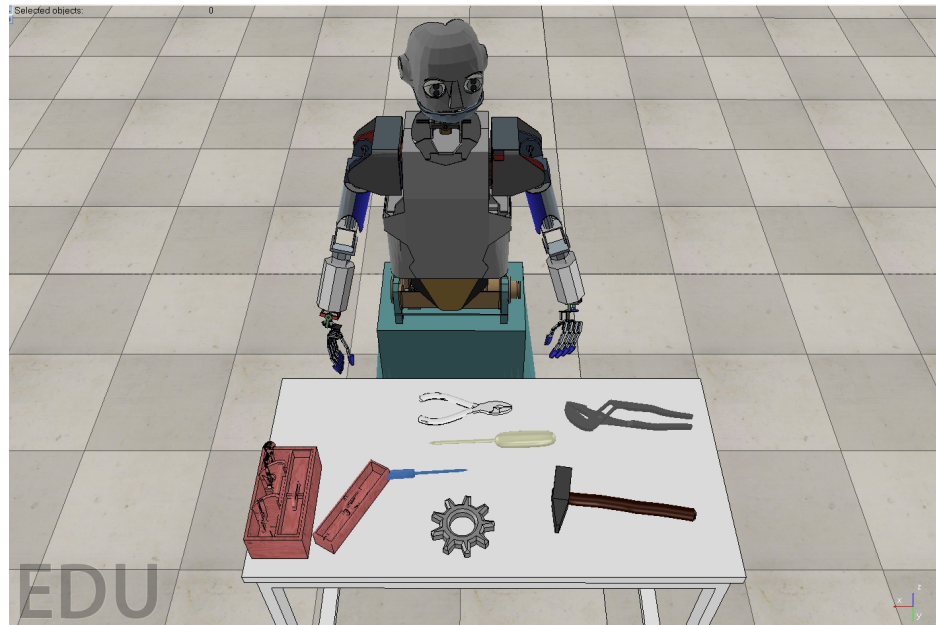


	Object
class	furniture
type	table
id	00000005
color	wood
X	+4.0000e-01
y	+1.6500e+00
Z	+4.5000e-01
alpha	+0.0000e+00
beta	+9.0000e+01
gamma	-9.0003e+01
prob	1

# Structures

## Relations

	Object
class	tool
type	screwdriver
id	00000002
color	Light-green
X	+4.0000e-01
y	+1.5750e+00
Z	+9.2000e-01
alpha	+3.6718e-05
beta	-8.6000e+01
gamma	+1.6234e+02
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	Object
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Z	+4.5000e-01
alpha	+0.0000e+00
beta	+9.0000e+01
gamma	-9.0003e-01
prob	1

The lighth-green screwdriver is **ON** the table



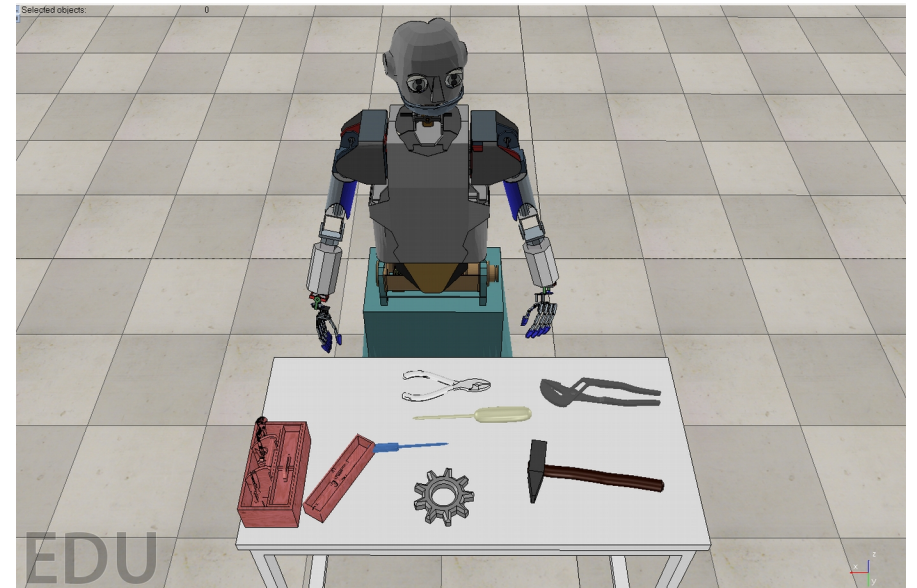
# Reasoning in ArmarX

## Reasoning Levels

Logical



```
OnTopOf (screwdriver2:tool, table5:furniture, thresh:number) ←  
  getZCoord (screwdriver2:tool, Z1) AND  
  getZCoord (table5:furniture, Z2) AND  
  getDistance (Z1, Z2, Distance) AND  
  Distance <= thresh
```



# Reasoning in ArmarX

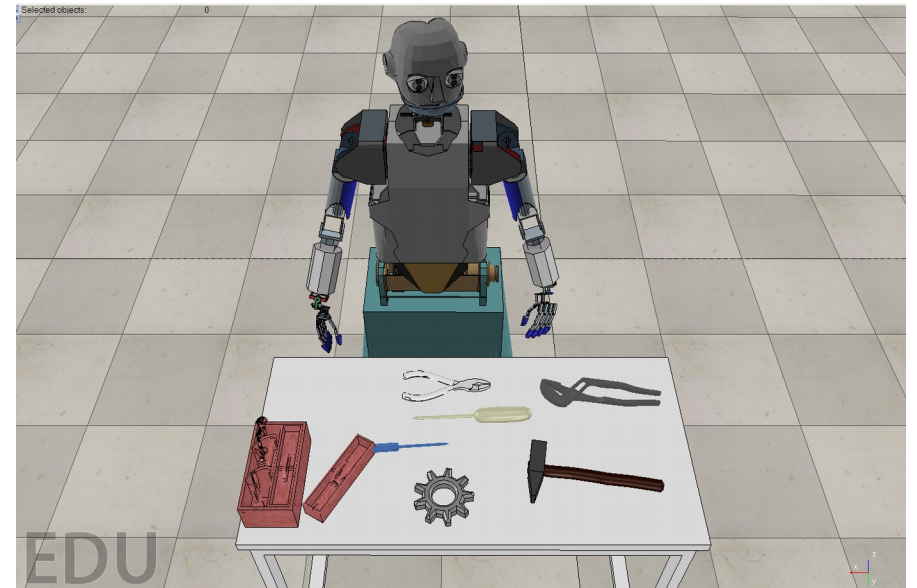
## Reasoning Levels

Logical



*Feature extractors*

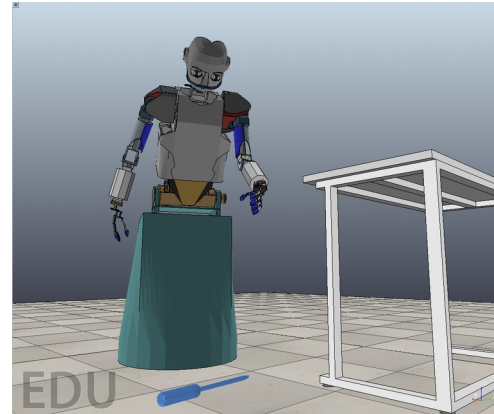
```
OnTopOf (screwdriver2:tool, table5:furniture, thresh:number) ←  
  getZCoord (screwdriver2:tool, Z1) AND  
  getZCoord (table5:furniture, Z2) AND  
  getDistance (Z1, Z2, Distance) AND  
  Distance <= thresh
```



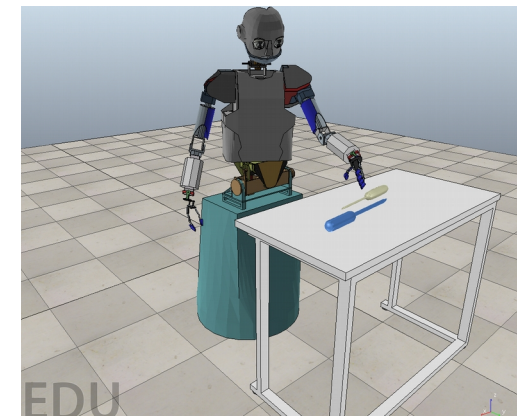


# Reasoning in ArmarX

## Reasoning Levels

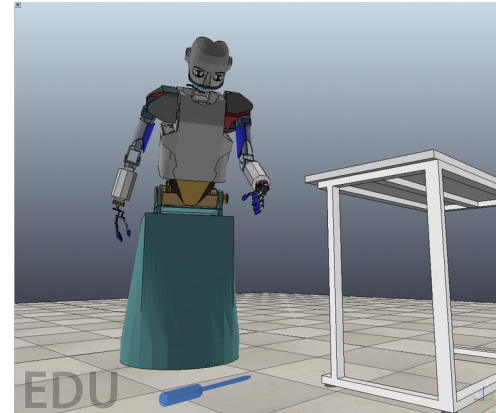


*What is the probability that the object detected by Armarx on the ground is a screwdriver? Moreover, what is the probability that this screwdriver is the blue one that was previously on table?*



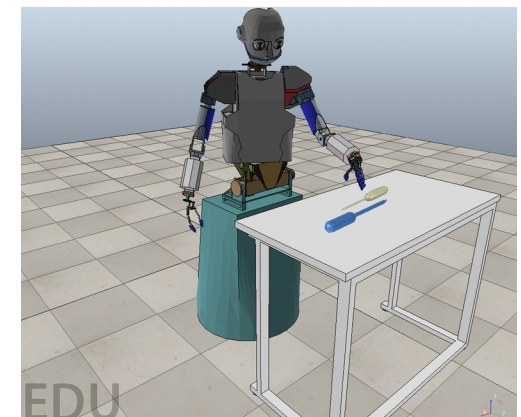
# Reasoning in ArmarX

## Reasoning Levels



*What is the probability that the object detected by Armarx on the ground is a screwdriver? Moreover, what is the probability that this screwdriver is the blue one that was previously on table?*

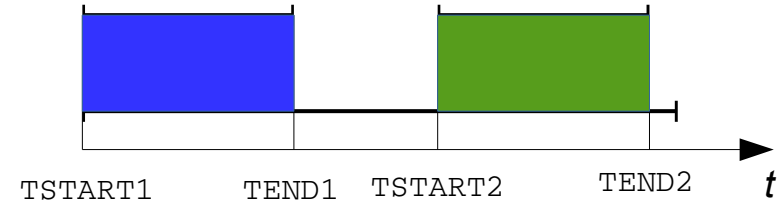
Update



# Reasoning in ArmarX

## Reasoning Levels

Logical      Statistical      Temporal



$P(X_1:t_1, X_2:t_2, \dots, X_n:t_n, TSTART_1:time, TEND_1:time)$

**BEFORE**

$Q(Y_1:t_1, Y_2:t_2, \dots, Y_m:t_m, TSTART_2:time, TEND_2:time)$

$\triangleq$

$TEND_1 < TSTART_2$

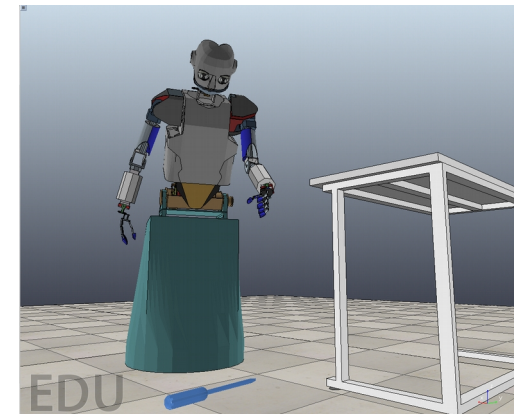
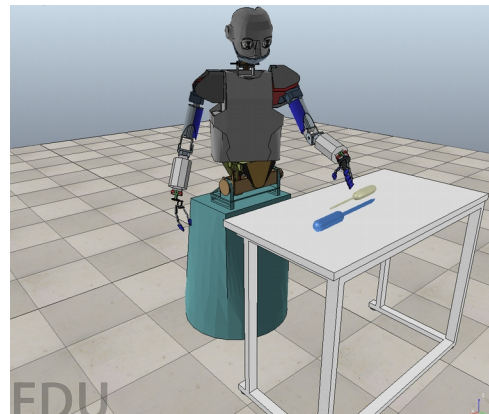
*Es:*

$OnTopOf(X:tool, Y:furniture, TSTART_1:time, TEND_1:time)$

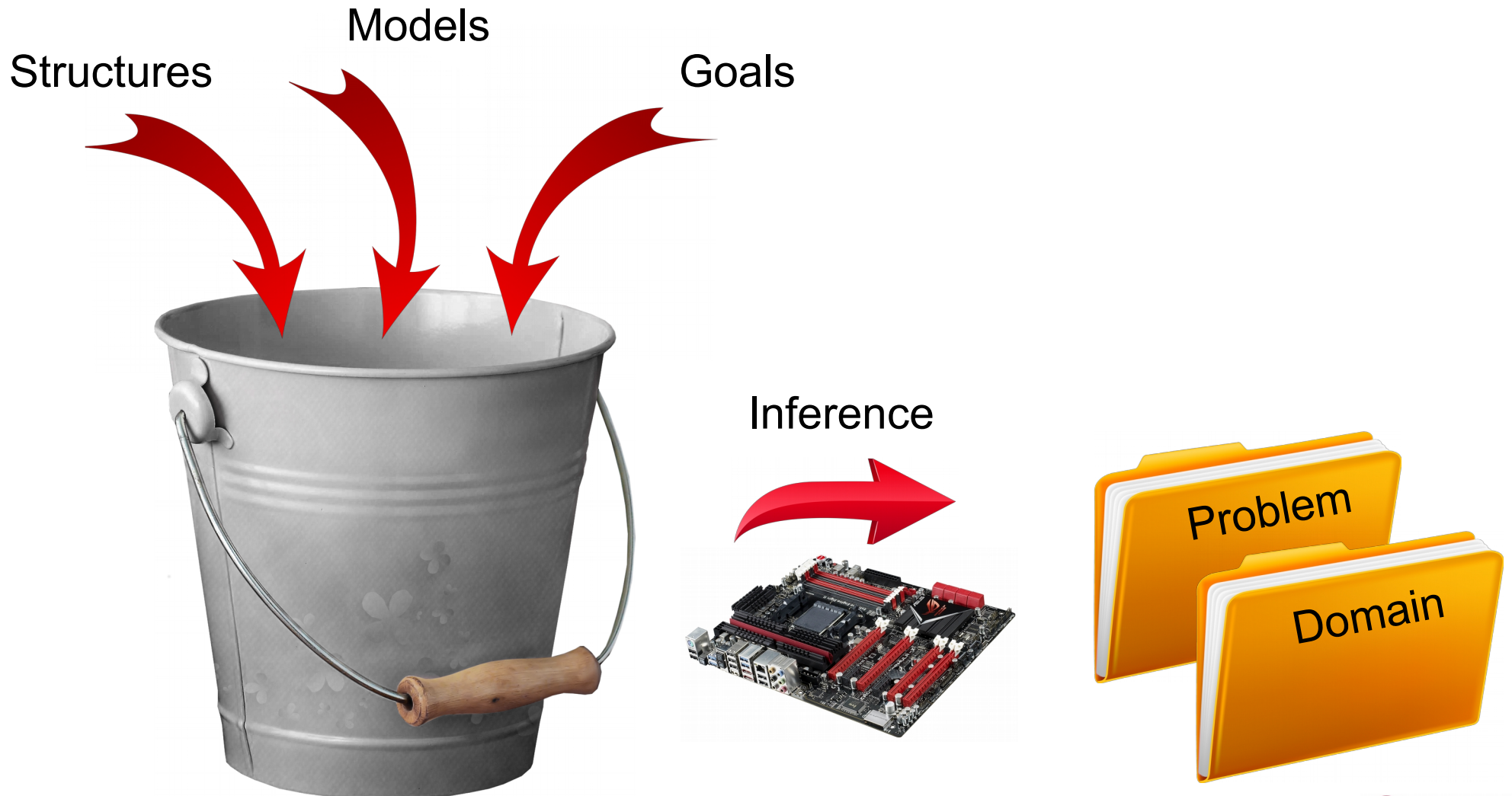
**BEFORE**

$On(X:tool, Z:structural, TSTART_2:time, TEND_2:time)$

$\triangleq TEND_1 < TSTART_2$

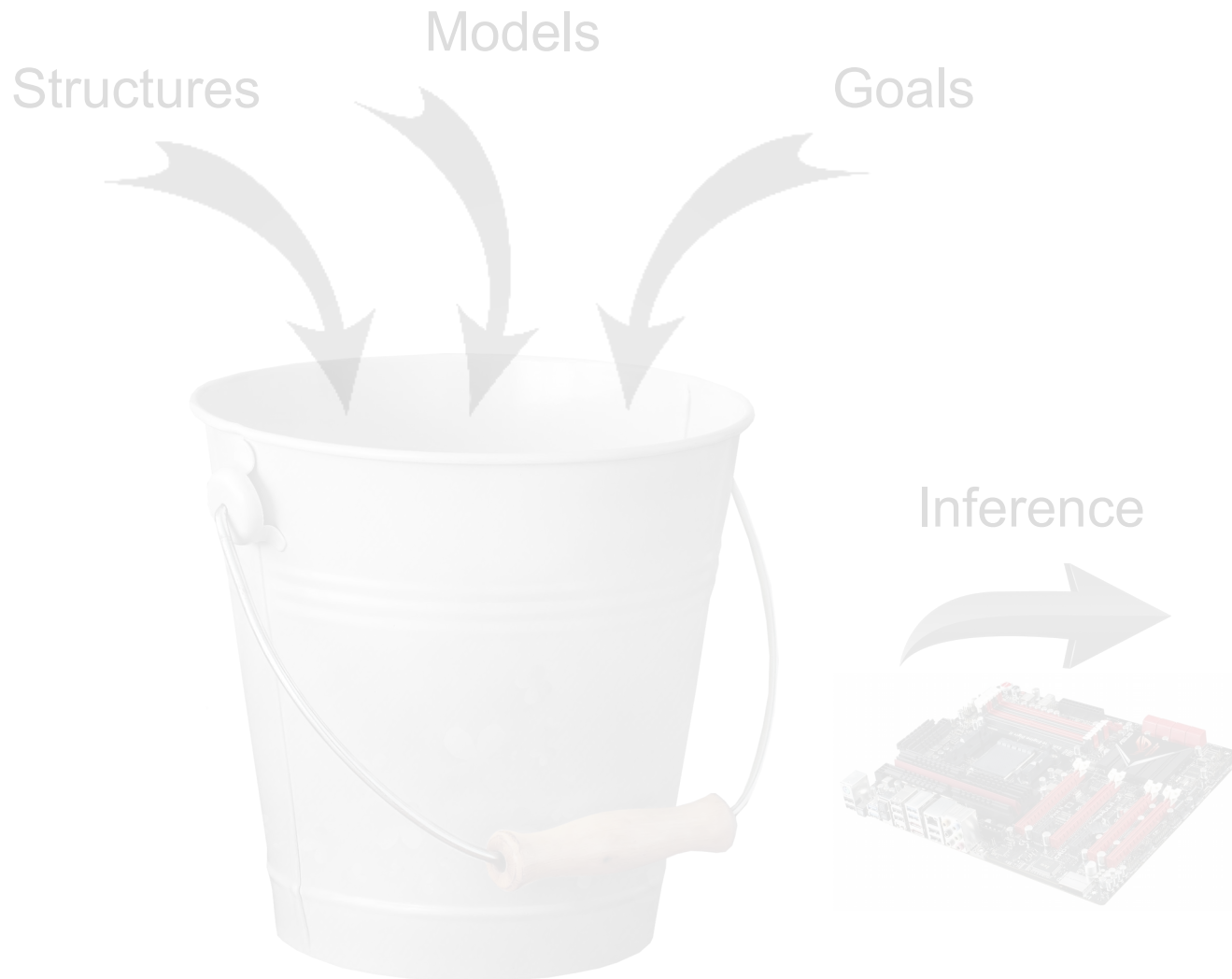


# Reasoning in ArmarX





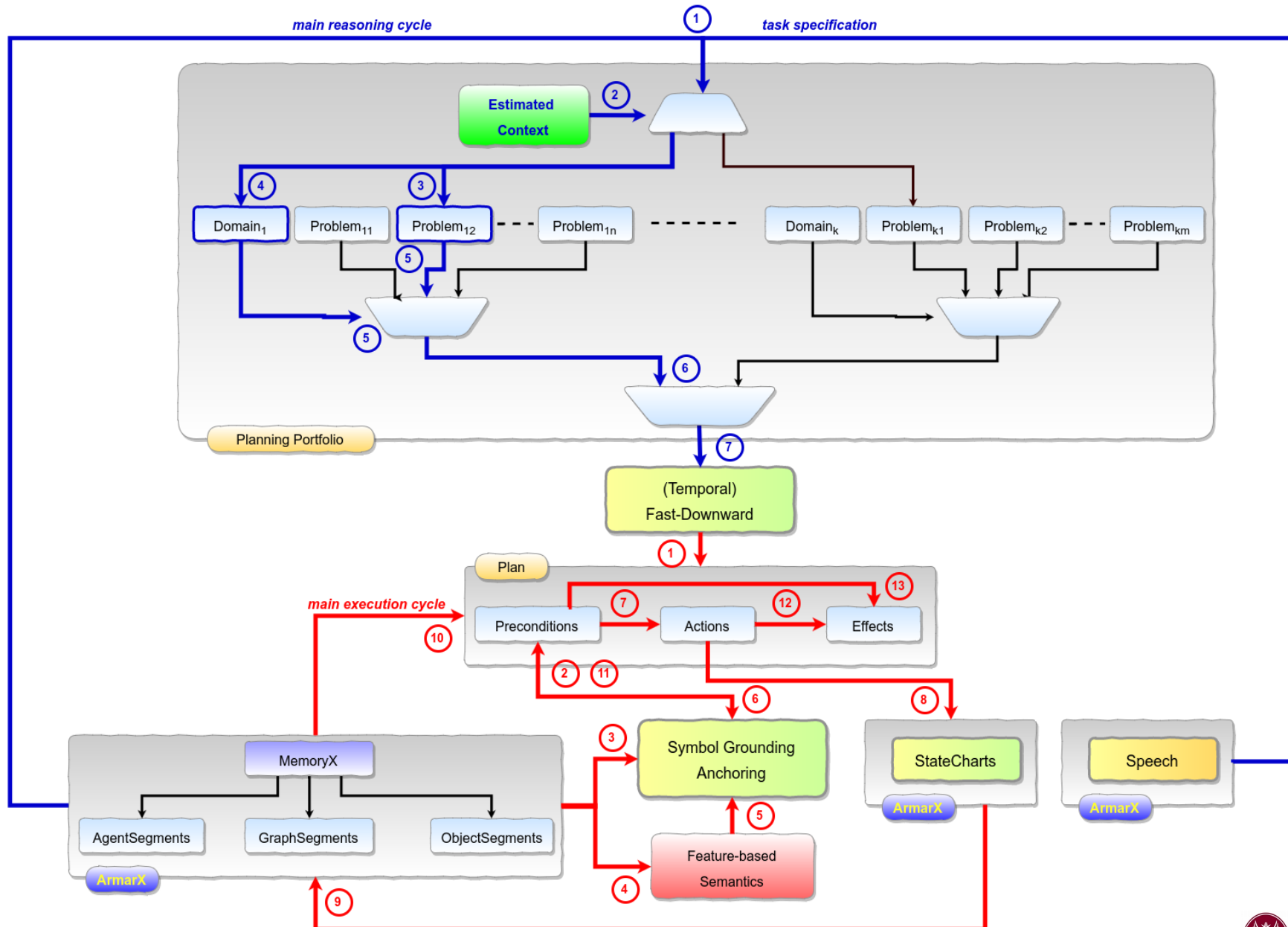
# Planning in ArmarX



## Planning Library



# Planning & Execution in ArmarX







Thanks

