iTaSC 2.0 Manual

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version 0.1

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Terminology

- **iTaSC:** The paradigm for task specification
- **Virtual Kinematic Chain (VKC):** Spatial relation model with ≥ 6 indpt. auxiliary coordinates χ_f + estimation + uncertainty χ_u.
- **Interaction Model (IM):** Similar as VKC, but returns H instead of J_f^{-1}
- **Constraint/Controller:** Output equation (=combination of χ_f and $\mathbf{q}$) and controller.
- **Robot:** Kinematic model of a robotic manipulator: $\mathbf{q}$ and uncertainty χ_u.
- **Object:** Kinematic model of an object and uncertainty χ_u.
- **SceneGraph:** Component that collect the spatial configuration of the elements in the Scene.
- **Scene:** Combination of SceneGraph, Robots and Objects: All elements and their pose in space.
- **Solver:** Algorithm to solve the desired joint output
- **Supervisor:** Implements a skill
- **Skill:** A specific combination of the configuration and coordination of Tasks
- **Task:** Combination of Constraint/Controller with VKC or IM (and/or Trajectory Generator)
- **Composite Task:** Combination/composition of tasks

Concept

How to make a new iTaSC application

- empty Scene
-
-
- .
  -
  -
-

Concept

How to make a new iTaSC application

- empty Scene
- add Robots and Objects
-
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    -
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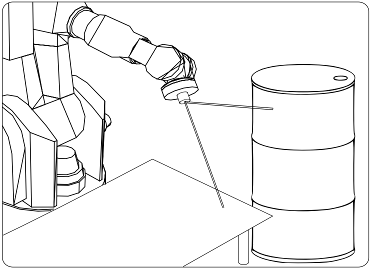
-



Concept

How to make a new iTaSC application

- empty Scene
- add Robots and Objects
- define Object Frames
- .
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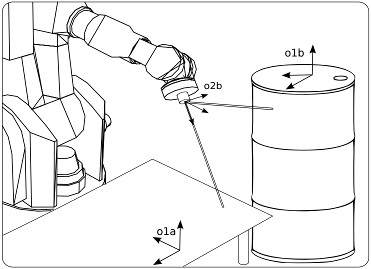

Concept

How to make a new iTaSC application

- empty Scene
- add Robots and Objects
- define Object Frames
- add SubTasks
  - Virtual Kinematic Chains
  -
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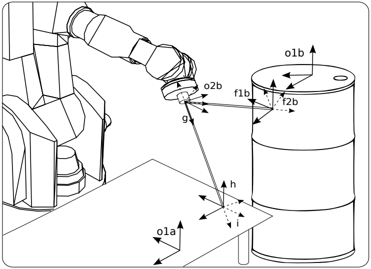
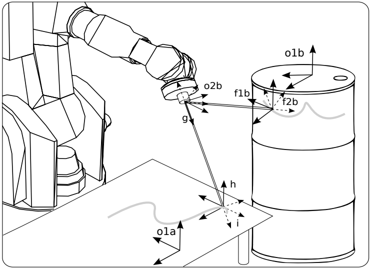


Concept

How to make a new iTaSC application

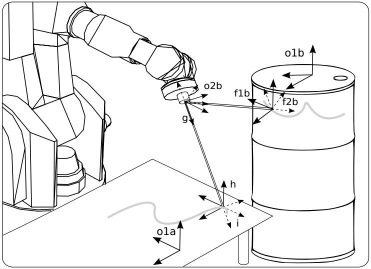
- empty Scene
- add Robots and Objects
- define Object Frames
- add SubTasks
  - Virtual Kinematic Chains
  - Constraint/Controller
-



Concept

How to make a new iTaSC application

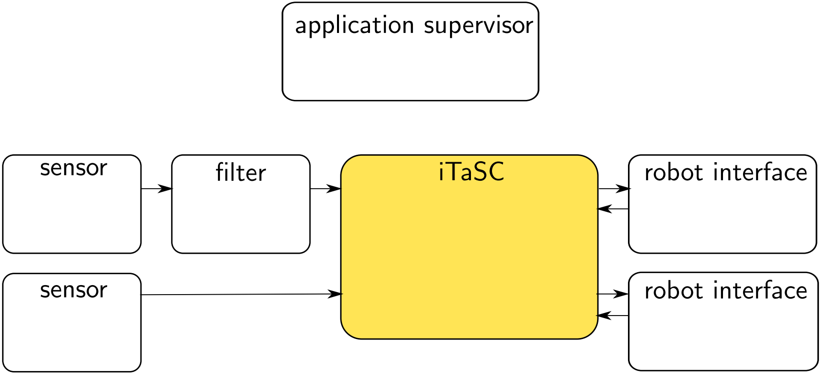
- empty Scene
- add Robots and Objects
- define Object Frames
- add SubTasks
  - Virtual Kinematic Chains
  - Constraint/Controller
- add a Solver



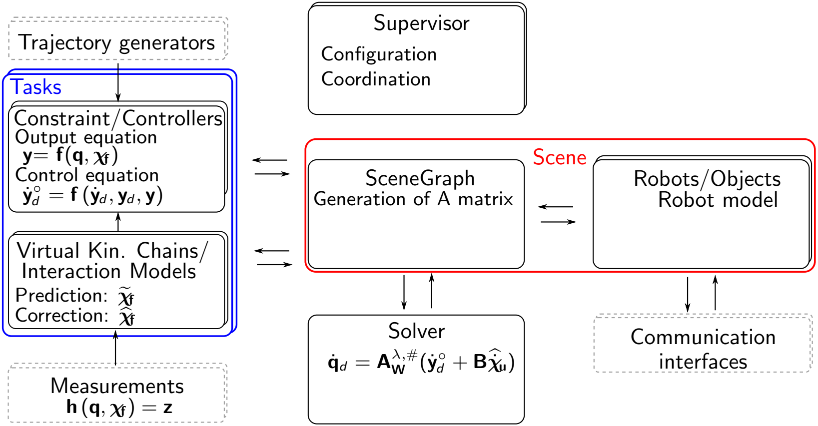
Concept: itasc_configuration.lua

```
local RobotLocation = rtt.Variable("KDL.Frame")
local TableLocation = rtt.Variable("KDL.Frame")

return rfsm.simple_state{
	entry=function()
		-- define the LOCATION of the base of the robots and objects
	RobotLocation:fromtab( {M={X_x=1,Y_x=0,Z_x=0,X_y=0,Y_y=1,Z_y=0,X_z=0,Y_z=0,Z_z=1},p={X=0.0,Y=0.0,Z=0.0}} )
	TableLocation:fromtab( {M={X_x=1,Y_x=0,Z_x=0,X_y=0,Y_y=1,Z_y=0,X_z=0,Y_z=0,Z_z=1},p={X=1.0,Y=1.0,Z=0.0}} )

		– add ROBOTS to the scene
		-- addRobot("<robot component name>", <kdl.Frame with location of the base in the scene>)
		addRobot("Robot", RobotLocation)
		addRobot("Table", TableLocation)

		-- add OBJECT FRAMES to the robots
		-- addObjectFrame("<objectFrameName you choose for this objectFrame>",
					"&lt;segment of robot where it is attached to>", "<robot component name>")
		addObjectFrame("endEffector_robot","ee", "Robot")
		addObjectFrame("top_table","top", "Table")

		-- add TASKS
		--	add VirtualKinematicChains or InteractionModels
		-- addVirtualKinematicChain("<name of the VKC component>","<1st objectFrameName as chosen above>",
						"<2nd objectFrameName as chosen above>")
		addVirtualKinematicChain("VKC_TraceLine", "endEffector_robot", "top_table")

		--	add Constraints/Controllers
		-- add ConstraintController("<name of the CC component>","<1st objectFrameName as chosen above>",
						"<2nd objectFrameName>", "<name of the VKC  to constrain>",<prioritynumber>)
		addConstraintController("CC_TraceLine", "endEffector_robot", "top_table", "VKC_TraceLine", 1)

		-- add SOLVERS
		addSolver("Solver")
	end,
}
```

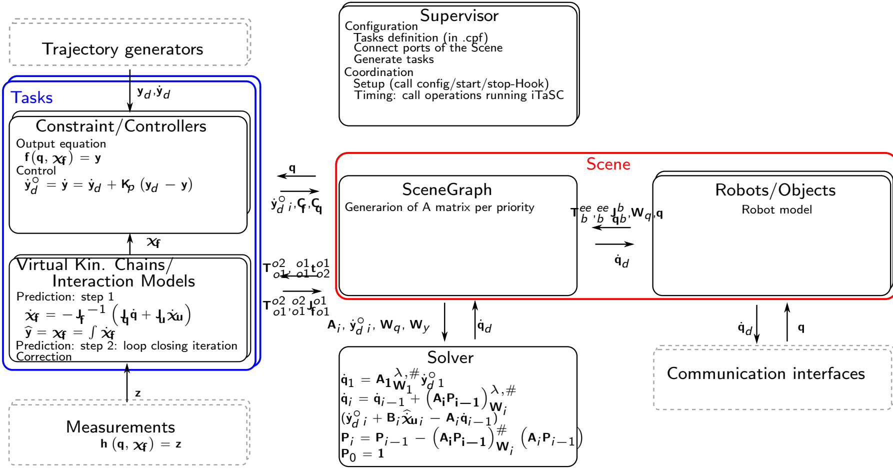
OROCOS components: Application level



OROCOS components: iTaSC level



OROCOS components: iTaSC level



OROCOS components: run.ops

1. import packages
2. create components
3. give components a frequency (setActivity), 0 for iTaSC level (timer triggered)
4. make components that will communicate with each other peers
5. load the FSM's in the Supervisor components
6. configure the Supervisors
7. load properties of the components
8. connect ports of the application level components
9. configure and start application level components
10. start the timer

Skills

- **Skill:** A specific combination of the **configuration and coordination** of Tasks
- Implemented using Finite State Machines (FSMs)
- **LUA** scripting language
- **Events** cause the FSMs to transition from one state to another
- Each **FSM** should be **OROCOS (RTT) independent**
- Each FSM is loaded in a **Supervisor component**, which contains the OROCOS (RTT) specific parts of the FSM
- 3 FSMs (levels) for an iTaSC application: **Application, iTaSC, Task** ⇒ your application is always in 3 states: one for each of level
- Each state shown on the next slide consists of two separate states in practice: eg. Configure ⇒ Configuring and Configured

Skills: Finite State Machines

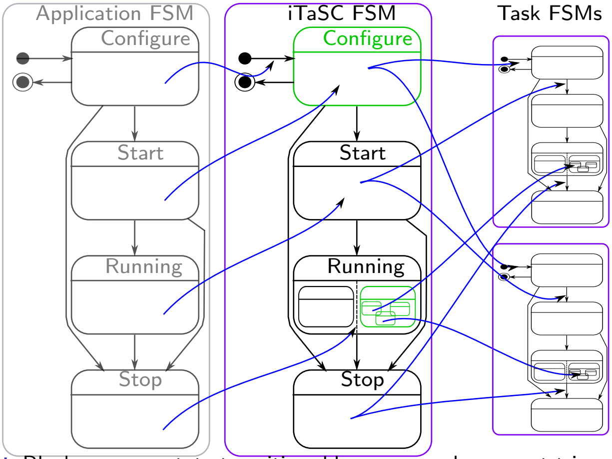


Figure: Black arrow = state transition, blue arrow = how event triggers state transition.

- iTaSC coordinator and task FSM are running sequentially
- GREEN = variation points → you may/should adapt this

Skills: The 3 levels of FSMs

1) Application FSM

- Coordinates the components **outside iTaSC** and iTaSC as a whole
- Put in this FSM the statements to configure/start/stop... the components on the application level, in the corresponding state

Skills: The 3 levels of FSMs

2) iTaSC FSM

- Coordinates the components **inside iTaSC, except the task components** (VKCs and CCs), they are threated as a whole
- Put in this FSM the statements to configure/start/stop…the components on the iTaSC level, in the corresponding state

3) Task FSMs

- Each Task FSM coordinates the **task components** of a certain task (coresponding with 1 Virtual Kinematic Chain, if one exists)
- Put in this FSM the statements to configure/start/stop…the components of a certain task, in the corresponding state

Skills: the Running state

- The running states (except application level) consists of **2 sequential parts**: an algorithm coordination part and a subFSM part
- **Algorithm coordination:** This part takes care of the right order of execution of the algorithm. The iTaSC algorithm coordination (running_itasc_coordination.lua) takes the lead and requests the algorithm coordination of the tasks at a certain moment (all tasks in parallel), by sending a triggerTasks event.
- **SubFSM:** The iTaSC subFSM (composite_task_fsm.lua) contains the actual behaviour you want from the application. It will trigger the subFSMs of the Tasks involved in a certain Composite Task (=Combination of Tasks, eg. the laser tracing on the barrel and the laser tracing on the table in the first example)

Skills: the Running state: subFSMs: example

composite_task_fsm.lua

- TraceFigureOnTable state
  - send event: “e_traceCircleOnTable”
- TraceFigureOnTableAndBarrel
  - send event: “e_traceCircleOnTable”
  - send event: “e_traceSquareOnBarrel”

running_trace_figure_on_table_fsm.lua

- TraceCircleOnTable
  - startCircleGenerator
  - activateTask (in RTT: W=1)
- HoldStill
  - stopCircleGenerator
  - activateTask

running_trace_line_on_barrel_fsm.lua

- TraceSquareOnBarrel
  - startSquareGenerator
  - activateTask
- HoldStill
  - stopSquareGenerator
  - activateTask

Tasks

- Tasks are **general**, separate packages, that **can be shared** eg. over the internet
- A task package should contain:
  - /scripts/ (FSM's and supervisor component in lua)
    - task_supervisor.lua
    - task_fsm.lua
    - running_task_coordination.lua
    - running_task_fsm.lua
  - /cpf/ (properties)
    - VKC_task.cpf
    - ...
  - /src/ (components)
    - VKC_task.hpp+cpp
    - or IM_task.hpp+cpp
    - CC_task.hpp+cpp
- A task package contains no info of scene, particular robots etc.

Conclusions

Steps to an implementation

- Design your application (first on paper)
  - Which Robots/Objects/Frames are involved
  - Virtual Kinematic Chains
  - Constraints/ Controllers
  - Solver
- Create/download task packages
- Change the FSM scripts on the three levels (application-iTaSC-task)
- Create run.ops and run.sh (to execute run.ops) file
- Test it!