A Full Immersive Assembly & Disassembly Simulation Using PTC/Division Reality

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Abstract

Virtual Reality (VR) has been a useful tool to share information and to take design decisions for the last 15 years, but it not being used at the same level to validate assembly and disassembly processes in manufacturing industries. This paper describes the approach of NIAR Virtual Reality Center (VRC) for this type of simulation and tries to point out what needs to be done to address the problems we came across along this project. Besides the technical comments related to how the database was prepared and the simulation itself, it also reports several issues related to human factors which affected/influenced the whole simulation. This paper presumes the reader has an intermediate knowledge about PTC/Division Reality.

VR Infrastructure

The NIAR VRC comprehends a semi and full immersive visualization system. The main image generator is driven by a SGI Onyx300 with two Infinite Reality 4 graphical pipelines, two Raster Managers per pipe, 8 MIPS R14K CPU's and 8 GB RAM. See Annex I for a detailed description.

The primary simulation equipment in this project relies on a NVIS' nVisor SX HMD, an electromagnetic 4-sensors motion tracker, Ascension's Nest of Birds with extended range transmitter, a pair of Fakespace's gesture sensitive Pinchgloves and a 5.1 channel surround sound system. These devices give a complete immersive perception [figure 1]. A Panoram's PanoWall 2K flat screen with two rear DLP-based projectors were used to show the audience what the user is seeing and performing [figure 2].

The dual channel stereo HMD receives 1280x1024 pixels at 60Hz image signals for left and right eyes with an adjustable inter-ocular distance knots and a diagonal field-of-view (FOV) of 60°. The instrumented glove and the motion tracker are directly connected to SGI Onyx300 by serial ports setup at 9600 and 38400 bauds respectively.

Figure 1: NIAR VRC full immersion VR devices

Figure 2: NIAR VRC flat screen rear projection room

The run-time simulation software PTC Division Reality 2000i2 DSU6 based on OpenGL Performer set to 32 bits mode was customized to connect the above described VR devices and has its *body actor* avatar modified to show only the hands, arms and fore-arms. The software graphical configuration, defined by the *visual actor*, is tuned to lock down APP, CULL and DRAW rendering stages for 3 free allocated CPUs; the shared memory arena is maximized; non-indexed geometry list is enabled and the frame rate control is set to LOCK mode for minimizing potential motion sickness. The *visual actor* is configured also to have 100%

overlapping images for left and right eyes, a fixed and pre-defined inter-ocular distance with a view-frustum of 46º. See Annex II.

A 6DOF motion tracking sensor is installed at back part of HMD visor (offset coordinated) and in each one of the glove's up-face sides. No signal filter is used in the motion tracking system. The glove's fingers commands is setup by *input actor* to fly forward/reward; to orbit the center clockwise/counterclockwise; to *key press* event commands; to *pick* and *drop* event command and to reset user position.

Database

Considering this simulation should be as interactive as possible due to the involvement of human factors, a minimum of 20 frames per second was defined to be a primary target. Several factors which could affect the simulation's frame-rate performance was taken in account, issues such as I/O connection bandwidth, motion tracker's latencies & delays, visualization software's API integration with VR devices and of-course, geometry polygon count and fill rate.

The database selected; a Forklift Lego Toy was provided in VRML 1.0 format model comprising about 100K polygons and not focused for real time rendering. The geometry was imported into 3D Studio MAX for manual and automatic polygonal reduction, shape simplification, removal of hidden faces and normal surface unification. After simplification the geometry became a 33K polygon database with independent parts [figure 3]. Because in the VR simulation the parts could be seen in any order and the polygon account was too small to require any level-of-detail (LOD) technique, no hierarchy scene graph to occlude hidden parts was necessary. Besides this, LOD could add a distraction effect to recognize part's shape at far distance not suitable for this case.

The data was exported to VRML 2.0 and imported to PTC Division Reality using *dvconvert* module with a customized *recipe file* using parameters to fast *tristrips*, adequate decimation settings and only one LOD. The converted *.bgf* proprietary format generated was only 1/5th in size of original model. The model was scaled to be compatible to a real Lego Toy and to a real hand size permitting easy pinching, handling or moving parts in assembly and disassembly tasks [figure 4]. The Division *body actor file* also had modified parameters of navigation. [See Annex III].

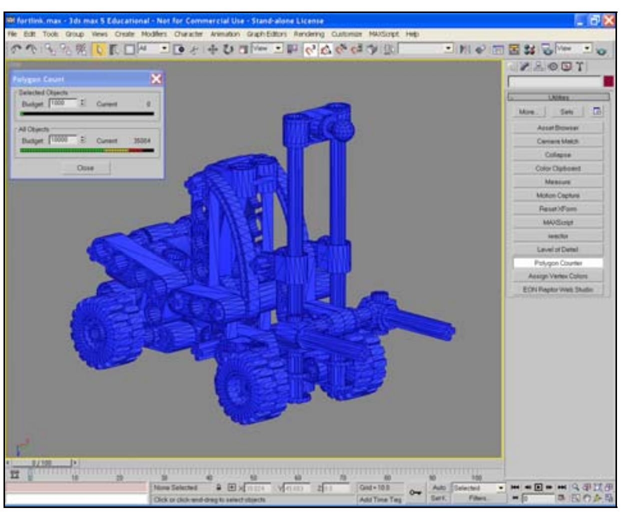


Figure 3: Model after polygon simplification at 3D Studio MAX

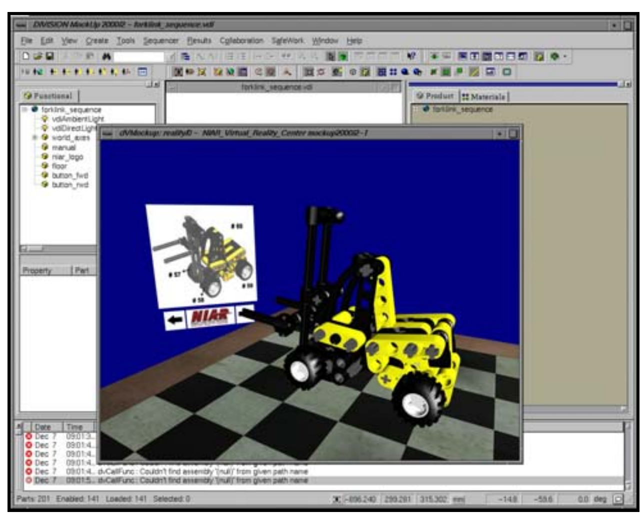


Figure 4: Final simulation model at PTC Division Reality

All bitmap *.jpg* textures were converted to *.vtx* and it was formatted to be power of two. Only 2 lights were used: head light and ambient light. A pre-shaded floor was added to give a better positional reference and an interactive manual to visually instruct how to assemble the Lego Toy was developed using billboard technique and behaviors.

Simulation

The primary goal for this simulation was to access how effective would be a virtual assembly over a real physical assembly task using a simple Forklift Lego Toy and compare human factors aspects. The level of knowledge retained after task completion and how close VR could mimic a real environment were the issues persuaded by NIAR Human Factors Lab and NIAR VRC.

The techniques developed in this simulation were passed to aircraft scenarios which are ordinarily found in design reviews of conception and manufacturing phases. For example, to validate a corporate jet's nose landing gear bay assembly sequence or to check if a roller bag can be fitted in a passenger's seat over-head bin [figure 5].

The simulation was entirely driven by PTC Division Reality's *event/action* engine with SGI. The events were defined to parts respond to, and the actions were executed in response to those events. Standard and user defined events were used in the *Behavioral Properties*. Sound was used to reinforce data acquisition's perception when events were completed such as, *touch*, *collide* or user defined *drop* events.

The geometry model was imported in its assembled condition, i.e. all *.bgf* parts had its position and orientation data already pre-defined in its final location. This information was very important in behavior's action commands to snap the parts to their appropriate location after a collision event between it and any other part. Considering all parts were descendents of one *parent part*, all their location were specified as relative and not global. This had facilitated to replicate the *property behavior* for any other part and because of that *dvAssemblyPosition* and *dvAssemblyOrientation* actions could be presented with null values in X, Y and Z coordinates. This is a very useful technique if you have several parts involved in the simulation.

Figure 5: IAI's aircraft nose landing gear virtual assembly

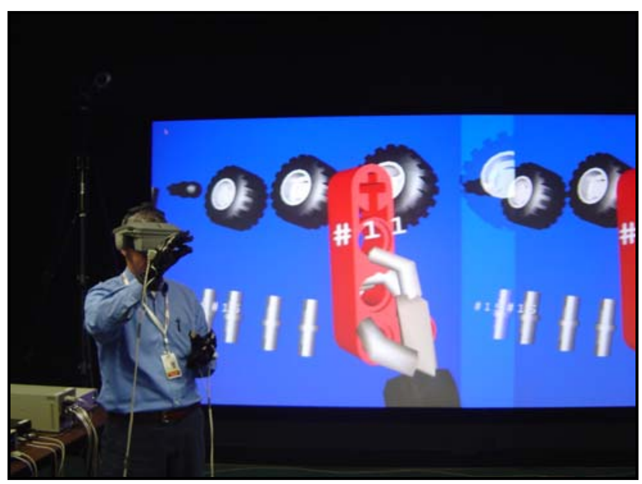


Figure 6: Natural gesture command to pinch and release parts

All parts which should be either touched and hand picked by user's virtual hand or collided with others which parts had their *collision property* setup with *collision volume* to *geometry*. The collision detection by

using the polygon boundary defined by the surface in the geometry file *.bgf* was accurate and useful but slows down the simulation's performance when several and complex geometry parts collide.
Under human factors point-of-view the natural gesture command to pick-up and move objects is to use two or more fingers, normally the thumb and index finger in the same hand. When fingers loose object's contact and the hand are opened the objects are released and dropped. The *behavior properties* were programmed according to that assumption [figure 6].

All parts participating in the interactive assembly and disassembly simulation had the same *behavior properties* as described below.
A local variable *%pinch* was defined and assigned value 0. When the manikin right hand was touching (i.e. colliding) a part, the variable *%pinch* was assigned to 1. If thumb and index finger was in contact (defined by *KeyPress* event), the *dvCall* action performed a Boolean evaluation to be equal to 1, and if true, a *user defined event pick* picked the part by the right hand using *dvBodyPick* action and it could be positioned according to hand movements. When thumb and index finger are not in contact (a *KeyRelease* event) the right hand dropped the part by using *dvDropBody* action and the part could not be moved any more.
A suggested technique to avoid unwanted touch after a part was picked and before it was dropped was to toggle *off/on* the *dvAssemblyCollisionMode* action.
The *Untouch* event put the *%pinch* variable back to 0. (If along of the time the part was been picked or moved and if it had a collision with another part, both parts involved were snapped to its final assemble location by *dvAssemblyPosition* and *dvAssemblyOrientation* actions). To indicate to the user that he/she had touched the part, a *dvAssemblyVisualTree* action was used to change the original part's color to red and a *dvAssemblyAudio* action is used to trigger a characteristic sound.
In assembly and disassembly simulation it is necessary to follow a sequence as stated in manual (virtual clipboard) instructions. Every time a touch event is triggered, a *dvAssemblyText* action is performed to show a part number related to assembly sequence [figure 7].

After the part's behaviors were completed all geometry parts are aligned in a front view plan and placed in a similar order to the real Lego Toy's layout. See [figure 8].

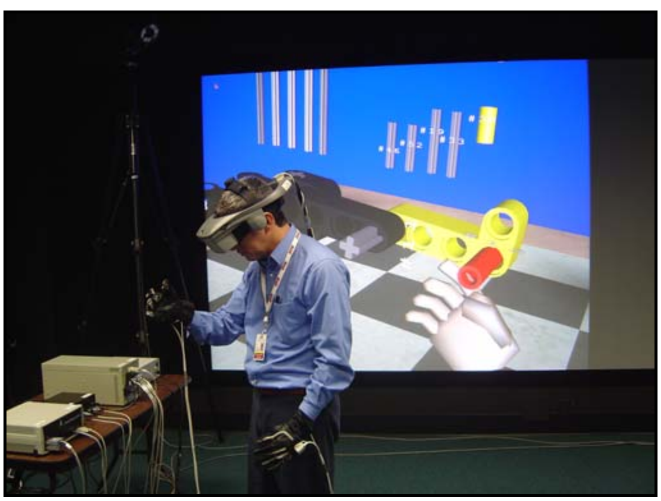


Figure 7: Behavioral events/actions in assembly task

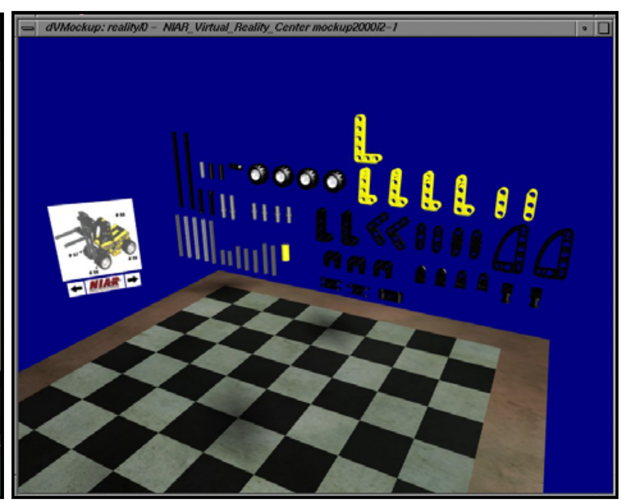


Figure 8: Parts layout according to real task simulation

A second behavioral property was developed to an interactive instructional manual. This floating manual, using texture and billboard techniques, which works like a real process chart, were pages could be scrolled forward and reward. The virtual manual was comprehended by a main screen, where *.vtx* texture is

visualized and two small buttons, left and right arrows, with collide and behavior properties defined to scroll the manual's pages.
A global variable *@page* was defined and assigned value 0. When the manikin right or left hand is contacting (a *touch* event) the forward or reward arrows buttons the variable *@page* is incremented by 1 or decremented by 1 respectively through *dvAssign* action and, a *user defined event scroll* was also triggered. As in the last behavioral properties, a *dvAssemblyAudio* action was used to inform the user when the instruction page was going to change. In the *user defined event scroll*, a *dvCall* action was used to compare *@page* variable to unique values associated to each manual's page. When the page had reached to last one, the *@page* variable was assigned again to 0.

Pinchglove commands to scroll the manual pages were also used and that would to avoid the collision between virtual hands and the left/right arrows buttons, speeding-up the simulation when the user was located too far from the virtual manual [figures 9 and 10].

To facilitate the user navigation all geometry parts were put under a *parent part* located at global coordinate origin it was configured to be the reference point to orbit the model when the user is resetting his/her position with the Pinchglove's command. A *KeyPress* event was used to trigger a *dvBodySetOrbitPoint* action.

In this full immersive simulation, Pinchglove was an important tool. With the glove, it was possible to pinch and move a part, reset the user to initial camera location, fly forward/reward; orbit a pivot point located at center of simulation and scroll forward/reward the pages of the virtual manual. See body and input actor on Annex III.

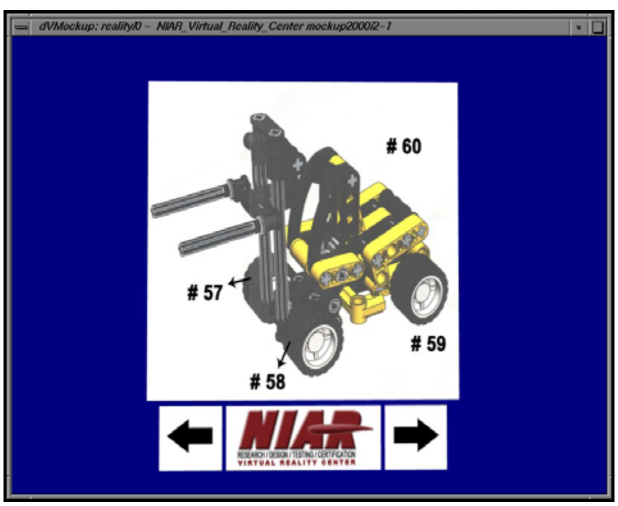


Figure 9: Interactive Virtual Manual

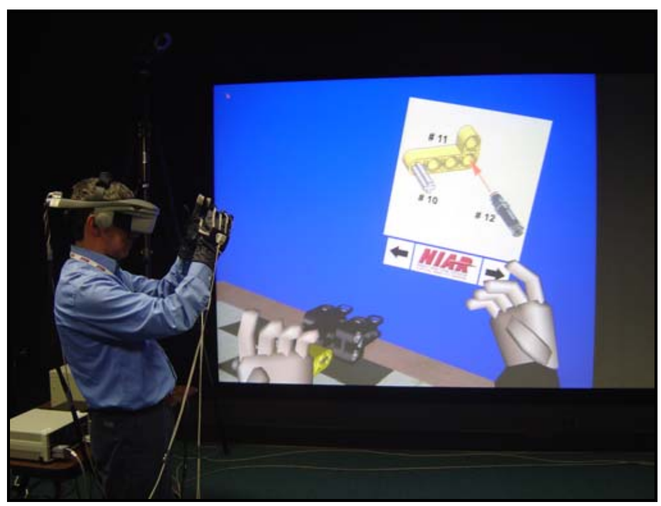


Figure 10: Virtual Manual been scrolled by right hand

Conclusion

PTC/Division Reality is robust virtual prototyping software for 3D visualization and simulation and it have been in the market for almost a decade now. Its full immersion and simulation capabilities explored in this small project allowed us extend it for more complex simulations.

In interactive simulations performed at NIAR VRC by experienced and non-experienced users we observed problems relating to:

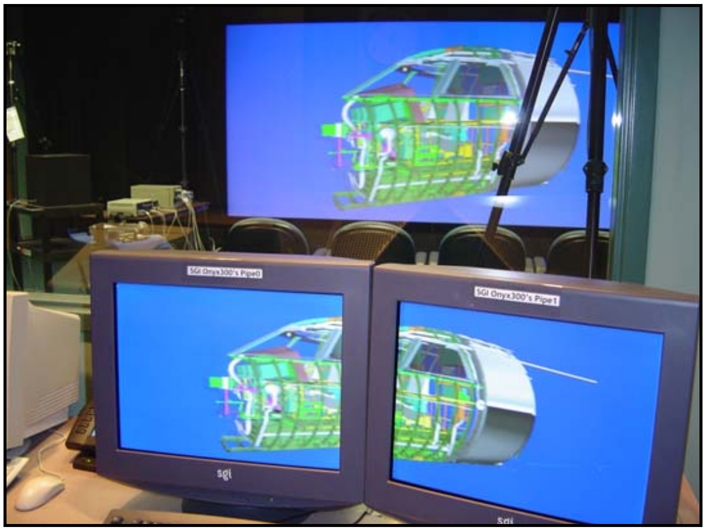
- Following the assembly's sequence due to the programming intrinsic characteristic which distinguishes similar parts to fit in only one location instead from the real Lego Toy environment where similar parts can be assembled indistinctly. In the current code, every time parts collide with one another, both are snapped to its final assembly location. A more natural assembly should use AI (artificial intelligence) coding techniques.
- Lack of force-feedback gloves, which prevents a part to penetrate another and includes collision detection solution involving three objects at same time – in this simulation: hand and two parts to be fit. Currently available force-feedback systems in the VR market can only involve two objects. For example, in aircraft assembly, a technician holds a screw driver (1^{st} object) to fasten a bolt (2^{nd} object) into a frame/skin joint (3^{rd} object).
- The virtual hand's finger representation does not rotate according to a real finger in pinch manipulation. This technological problem could be solved mixing Immersion's Cyberglove and Fakespace's Pinchglove features in only one glove.
- Picking and moving objects was difficult for new users because their lack of skill in handling the Fakespace's Pinchglove. This and others interface paradigms can be a serious problem to eventual users who are not briefed in prior.

A full immersion virtual reality simulation that involves assembly and disassembly mechanical tasks is a challenging project. Besides real-time quality rendering, several human factors and ergonomics issues such as but not limited to; adequate time response - which in general is agreed to be less than 100ms as a maximum value acceptable; natural gesture commands; good field-of-view, non intrusive and comfortable VR devices - while we wait for a more pervasive VR technology; all those need to be addressed in satisfactory way, under the penalty the simulation be disbelieved by any user.

Today in VR, real-time ergonomic simulations can be used to solve anthropometrical problems but would not give any final word on issues related to cognitive aspects. Mixing real objects and surrounding them by virtual ones – or what is called Augmented Virtuality – have been a primary choice solution to address that lack of cognition in several virtual reality centers of aircraft manufactures. In fact, at conception or manufacturing phases, VR does not eliminate the entire necessity to build physical mockups but it really contributes to speed-up design decisions when complexity and variations are not very well understood by avoiding the unnecessary, time consuming and costly intermediate physical prototypes.

Annex I

SGI Onyx300 specification



PTC/Division from NIAR VRC Control Room

SGI Onyx300

Unix IRIX hinv –v **command:**

```
8 600 MHZ IP35 Processors
CPU: MIPS R14000 Processor Chip Revision: 2.4
FPU: MIPS R14010 Floating Point Chip Revision: 2.4
CPU 0 at Module 001c22/Slot 0/Slice A: 600 Mhz MIPS R14000 Processor Chip (enabled)
Processor revision: 2.4. Scache: Size 4 MB Speed 300 Mhz  Tap 0xa
CPU 1 at Module 001c22/Slot 0/Slice B: 600 Mhz MIPS R14000 Processor Chip (enabled)
Processor revision: 2.4. Scache: Size 4 MB Speed 300 Mhz  Tap 0xa
CPU 2 at Module 001c22/Slot 0/Slice C: 600 Mhz MIPS R14000 Processor Chip (enabled)
Processor revision: 2.4. Scache: Size 4 MB Speed 300 Mhz  Tap 0xa
CPU 3 at Module 001c22/Slot 0/Slice D: 600 Mhz MIPS R14000 Processor Chip (enabled)
Processor revision: 2.4. Scache: Size 4 MB Speed 300 Mhz  Tap 0xa
CPU 4 at Module 001c24/Slot 0/Slice A: 600 Mhz MIPS R14000 Processor Chip (enabled)
Processor revision: 2.4. Scache: Size 4 MB Speed 300 Mhz  Tap 0xa
CPU 5 at Module 001c24/Slot 0/Slice B: 600 Mhz MIPS R14000 Processor Chip (enabled)
Processor revision: 2.4. Scache: Size 4 MB Speed 300 Mhz  Tap 0xa
CPU 6 at Module 001c24/Slot 0/Slice C: 600 Mhz MIPS R14000 Processor Chip (enabled)
Processor revision: 2.4. Scache: Size 4 MB Speed 300 Mhz  Tap 0xa
CPU 7 at Module 001c24/Slot 0/Slice D: 600 Mhz MIPS R14000 Processor Chip (enabled)
Processor revision: 2.4. Scache: Size 4 MB Speed 300 Mhz  Tap 0xa
Main memory size: 8192 Mbytes
Instruction cache size: 32 Kbytes
Data cache size: 32 Kbytes
Secondary unified instruction/data cache size: 4 Mbytes
Memory at Module 001c22/Slot 0: 4096 MB (enabled)
Bank 0 contains 1024 MB (Premium) DIMMS (enabled)
Bank 1 contains 1024 MB (Premium) DIMMS (enabled)
Bank 2 contains 1024 MB (Premium) DIMMS (enabled)
Bank 3 contains 1024 MB (Premium) DIMMS (enabled)
Memory at Module 001c24/Slot 0: 4096 MB (enabled)
Bank 0 contains 1024 MB (Premium) DIMMS (enabled)
Bank 1 contains 1024 MB (Premium) DIMMS (enabled)
Bank 2 contains 1024 MB (Premium) DIMMS (enabled)
Bank 3 contains 1024 MB (Premium) DIMMS (enabled)
Integral SCSI controller 0: Version QL12160, low voltage differential
Disk drive: unit 1 on SCSI controller 0 (unit 1)
Disk drive: unit 2 on SCSI controller 0 (unit 2)
Integral SCSI controller 1: Version QL12160, single ended
CDROM: unit 4 on SCSI controller 1
Integral SCSI controller 6: Version QL12160, low voltage differential
```

```
Disk drive: unit 1 on SCSI controller 6 (unit 1)
Disk drive: unit 2 on SCSI controller 6 (unit 2)
Integral SCSI controller 7: Version QL12160, low voltage differential
Integral SCSI controller 8: Version QL12160, low voltage differential
Integral SCSI controller 9: Version QL12160, low voltage differential
IOC3/IOC4 serial port: tty3
IOC3/IOC4 serial port: tty4
IOC3/IOC4 serial port: tty5
IOC3/IOC4 serial port: tty6
Graphics board: InfiniteReality4
Graphics board: InfiniteReality4
Integral Fast Ethernet: ef0, version 1, module 001c22, pci 4
Fast Ethernet: ef1, version 1, module 001c24, pci 4
Iris Audio Processor: version RAD revision 13.0, number 1
PCI Adapter ID (vendor 0x10a9, device 0x0005) PCI slot 2
PCI Adapter ID (vendor 0x1077, device 0x1216) PCI slot 1
PCI Adapter ID (vendor 0x10a9, device 0x0003) PCI slot 4
PCI Adapter ID (vendor 0x11c1, device 0x5802) PCI slot 5
PCI Adapter ID (vendor 0x1077, device 0x1216) PCI slot 2
PCI Adapter ID (vendor 0x1077, device 0x1216) PCI slot 1
PCI Adapter ID (vendor 0x10a9, device 0x0003) PCI slot 4
PCI Adapter ID (vendor 0x11c1, device 0x5802) PCI slot 5
IOC3/IOC4 external interrupts: 1
IOC3/IOC4 external interrupts: 2
HUB in Module 001c22/Slot 0: Revision 2 Speed 200.00 Mhz (enabled)
HUB in Module 001c24/Slot 0: Revision 2 Speed 200.00 Mhz (enabled)
IP35prom in Module 001c22/Slot n0: Revision 6.180
IP35prom in Module 001c24/Slot n0: Revision 6.180
USB controller: type OHCI
USB controller: type OHCI
USB Human Interface Device: device id 0 type keyboard
USB Human Interface Device: device id 0 type mouse
USB Human Interface Device: device id 1 type mouse
USB Human Interface Device: device id 1 type keyboard
```

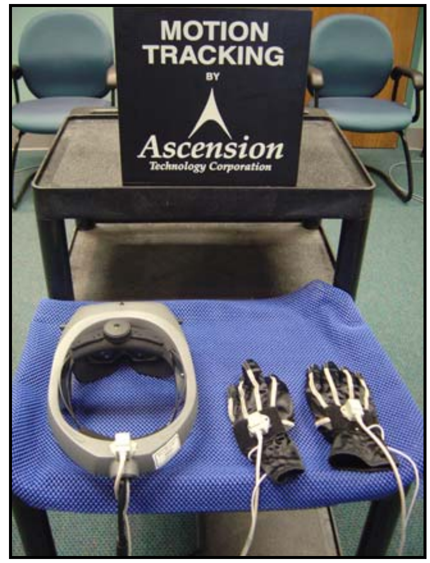
Unix IRIX gfxinfo **command:**

```
Graphics board 0 is "KONAD" graphics.
Managed (":0.0") 1280x1024
Display has 8 channels
4 GEs (of 4), occmask = 0x0f
4MB external BEF ram, 32bit path
2 RM11 boards (of 2) 1/1/0/0
Texture Memory: 1024MB/1024MB/-/-
Extra-Large pixel depth
32K cmap, 64K external gamma
Channel 0:
Origin = (0,0)
Video Output: 1280 pixels, 1024 lines, 60.02Hz (1280x1024_60_nVisorSX.vfo)
Graphics board 1 is "KONAD" graphics.
Managed (":0.1") 1280x1024
Display has 2 channels
4 GEs (of 4), occmask = 0x0f
4MB external BEF ram, 32bit path
2 RM11 boards (of 2) 1/1/0/0
Texture Memory: 1024MB/1024MB/-/-
Extra-Large pixel depth
32K cmap
Channel 0:
Origin = (0,0)
Video Output: 1280 pixels, 1024 lines, 60.02Hz (1280x1024_60_nVisorSX.vfo)
```

Annex II

PTC/Division Reality NIAR VRC customized default.reg file for SGI Onyx300

PTC/Division Reality customized to a stereo HMD using two graphical pipe



HMD, Pinchgloves and motion tracker

NIAR VRC default.reg file

```
#***************************************************************#
#                                                               #
#         NIAR_WSU CUSTOMIZATIONS FOR MOCKUP2000I2              #
#                                                               #
#      Customized by Fernando F Toledo - NIAR VR Center.        #
#          No modification is permitted without                 #
#               previous authorization.                         #
#                                                               #
#***************************************************************#

#******************************************************************
# Declarations for the  serial ports on SGI ONYX300
# referenced by the input actor configuration.
#******************************************************************
# Onyx300's serial port3 for PinchGlove
[${$AUTO/os/sysname}==IRIX64]:input/port3=/dev/ttyd3
# Onyx300's serial port4 for Nest_of_Birds
[${$AUTO/os/sysname}==IRIX64]:input/port4=/dev/ttyd4
# Onyx300's serial port5 for Cyberglove
[${$AUTO/os/sysname}==IRIX64]:input/port5=/dev/ttyd5


#*************************************************************
#         General Optimization Configurations
#*************************************************************

system/dvs/parameters=-E
system/dvs/Actors/agent/executable=agent
system/dvs/Actors/audio/executable=vcaudio
system/dvs/Actors/body/executable=vcbody_fullgui
system/dvs/Actors/body/parameters=-gui
system/dvs/Actors/body/firstProcessor=3
system/dvs/Actors/input/executable=vcinput
system/dvs/Actors/input/firstProcessor=3
system/dvs/Actors/collide/executable=vccollide
system/dvs/Actors/visual/executable=${visual/default/executable}
system/dvs/Actors/visual/executable=vcvisual
system/dvs/Actors/visual/firstProcessor=1
```

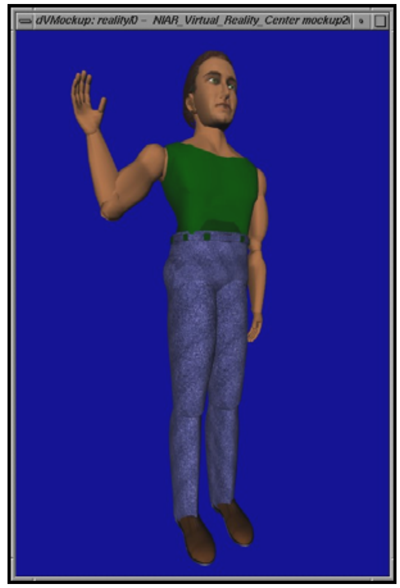
```
system/dvs/Application/parameters=-load
system/dvs/systemname=mockup2000i2
system/dvs/memsize=16194304

system/dvs64/parameters=-E
system/dvs64/Actors/agent/executable=agent
system/dvs64/Actors/audio/executable=vcaudio
system/dvs64/Actors/body/executable=vcbody_fullgui
system/dvs64/Actors/body/parameters=-gui
system/dvs64/Actors/body/fisrtProcessor=3
system/dvs64/Actors/input/executable=vcinput
system/dvs64/Actors/input/fisrtProcessor=2
system/dvs64/Actors/collide/executable=vccollide
system/dvs64/Actors/visual/executable=${visual/default/executable}
system/dvs64/Actors/visual/executable=vcvisual
system/dvs64/Actors/visual/fisrtProcessor=1
system/dvs64/Application/parameters=-load
system/dvs64/systemname=mockup_64
system/dvs64/memsize=16194304

#---additional configurations---------------------------------------------
[${$AUTO/environment/DPL_PERF}!=]:visual/general/dplobjectfilecachesize=521
[${$AUTO/environment/DPL_PERF}!=]:visual/general/dpltexmapfilecachesize=63
[${$AUTO/environment/DPL_PERF}!=]:visual/general/dplmaterialfilecachesize=63
[${$AUTO/environment/DPL_PERF}!=]:visual/general/dplmaterialitemcachesize=257
[${$AUTO/environment/DPL_PERF}!=]:visual/general/dplhandlecachesize=521
[${$AUTO/environment/DPL_PERF}!=]:visual/general/vcobjectcachesize=521
[${$AUTO/environment/DPL_PERF}!=]:visual/general/entitycachesize=521
[${$AUTO/environment/DPL_PERF}!=]:visual/general/visualcachesize=521
[${$AUTO/environment/DPL_PERF}!=]:visual/general/verbosity=on
#[${$AUTO/environment/DPL_PERF}!=]:visual/general/dplWarnLevel=debug

#---- INTEROCCULAR DISTANCE SETUP --------------------------------
#user/default/iod=0.030
user/default/iod=0.020

#--- PERFORMER ARENA SIZE in MBytes ------------------------------------------
[${$AUTO/environment/DPL_PERF}!=]:visual/configdata/SharedArenaSize=490
#[${$AUTO/environment/DPL_PERF}!=]:visual/configdata/SharedArenaSize=1900
#[${$AUTO/environment/DPL_PERF}!=]:visual/configdata/SharedArenaBase=101a8000
system/mockup2000i2/memaddr=0x39ae0000

#--- CACHE SIZE (it must to be prime mumbers)------------------------------------
visual/caches/dpl/partfile=16381
visual/caches/dpl/materialfile=241
visual/caches/dpl/materialitem=1013
visual/caches/dpl/handle=25913
visual/caches/vc/entity=16381
visual/caches/vc/attribute=31859

#**********************************************************************
#                   INPUT ACTOR CONFIGURATIONS
#**********************************************************************
**********************************************************************
#               pinch_niar2 CONFIGURATION
#   KEYBOARD + PINCH GLOVE + NEST OF BIRDS TRACKING HEAD & HANDS
#**********************************************************************
input/pinch_niar2/devices/wintracker/PRESENT=yes
input/pinch_niar2/devices/wintracker/DEVICESL=input/wintracker
input/pinch_niar2/devices/wintracker/SAMPLEHZ=60
input/pinch_niar2/devices/wintracker/DEVICEADDR=local/0

input/pinch_niar2/devices/nestbird/PRESENT=yes
input/pinch_niar2/devices/nestbird/units=m
input/pinch_niar2/devices/nestbird/angles=degrees
input/pinch_niar2/devices/nestbird/DEVICESL=input/serbird
input/pinch_niar2/devices/nestbird/DEVICEADDR=${input/port4}
input/pinch_niar2/devices/nestbird/SAMPLEHZ=60
input/pinch_niar2/devices/nestbird/AUTOBAUD=off
input/pinch_niar2/devices/nestbird/BAUD=38400
```

```
input/pinch_niar2/devices/pinch3/PRESENT=yes
input/pinch_niar2/devices/pinch3/DEVICESL=input/pinch
input/pinch_niar2/devices/pinch3/SAMPLEHZ=60
input/pinch_niar2/devices/pinch3/DEVICEADDR=${input/port3}
input/pinch_niar2/devices/pinch3/AUTOBAUD=off
input/pinch_niar2/devices/pinch3/BAUD=9600

input/pinch_niar2/sensors/head/DEVICENAME=wintracker
input/pinch_niar2/sensors/head/NUMBER=0

input/pinch_niar2/sensors/head/DEVICENAME=nestbird
input/pinch_niar2/sensors/head/NUMBER=1
input/pinch_niar2/sensors/head/units=m
input/pinch_niar2/sensors/head/angles=degrees
input/pinch_niar2/sensors/head/worldPos=0 0 0
input/pinch_niar2/sensors/rightHand/DEVICENAME=nestbird
input/pinch_niar2/sensors/rightHand/NUMBER=2
input/pinch_niar2/sensors/rightHand/SENSORORIENTATION=0 0 90
input/pinch_niar2/sensors/leftHand/DEVICENAME=nestbird
input/pinch_niar2/sensors/leftHand/NUMBER=3
input/pinch_niar2/sensors/leftHand/SENSORORIENTATION=180 180 90

input/pinch_niar2/vkbs/head/DEVICENAME=wintracker
input/pinch_niar2/vkbs/head/NUMBER=0
input/pinch_niar2/vkbs/head/mappings/BUTTON_1=BUTTON_5
input/pinch_niar2/vkbs/head/mappings/BUTTON_2=BUTTON_3

input/pinch_niar2/vkbs/hand/DEVICENAME=pinch3
input/pinch_niar2/vkbs/hand/NUMBER=0
#---right hand--- mapping from little to index finger----------
input/pinch_niar2/vkbs/hand/mappings/BUTTON_5=4
input/pinch_niar2/vkbs/hand/mappings/BUTTON_6=BUTTON_11
input/pinch_niar2/vkbs/hand/mappings/BUTTON_7=BUTTON_1
input/pinch_niar2/vkbs/hand/mappings/BUTTON_8=3
#input/pinch_niar2/vkbs/hand/mappings/BUTTON_9=A
#---left hand--- mapping from little to index finger----------
input/pinch_niar2/vkbs/hand/mappings/BUTTON_0=5
input/pinch_niar2/vkbs/hand/mappings/BUTTON_1=BUTTON_10
input/pinch_niar2/vkbs/hand/mappings/BUTTON_2=BUTTON_2
input/pinch_niar2/vkbs/hand/mappings/BUTTON_3=1
#input/pinch_niar2/vkbs/hand/mappings/BUTTON_4=a


#*********************************************************************
#                    VISUAL ACTOR CONFIGURATIONS
#*********************************************************************
#**********************************************************************
#  niar_hmd100: PIPE0/PIPE1 & 100% Overlap HEAD-MOUNTED DISPLAY & HEAD
#               and HANDS TRACKING & PINCH GLOVE
#**********************************************************************
#---- config niar_hmd100 -------------------
config/niar_hmd100/input/config=pinch_niar2
config/niar_hmd100/visual/config=nvisorsx100
config/niar_hmd100/body/config=pinch_hmd
body/pinch_hmd/bodyFile=niar_pinch

#--- 2@1280x1024_P01 - ONYX300 IR4 2 PIPES CONFIGURATION FOR HMD ----------------
visual/configs/2@1280x1024_p01/configdata/OptimiseGeometry=TRUE
visual/configs/2@1280x1024_p01/configdata/CullFace=TRUE
visual/configs/2@1280x1024_p01/configdata/EnvironmentLighting=TRUE
visual/configs/2@1280x1024_p01/configdata/IndexedGeometry=FALSE
visual/configs/2@1280x1024_p01/configdata/CompressedTextures=FALSE
visual/configs/2@1280x1024_p01/configdata/ProcessModel=APP_CULL_DRAW
visual/configs/2@1280x1024_p01/configdata/ProcessLockdown=APPCULLDRAW
visual/configs/2@1280x1024_p01/configdata/GeometryLoaders=TRUE
visual/configs/2@1280x1024_p01/configdata/ReportTextureSpace=TRUE
visual/configs/2@1280x1024_p01/configdata/MultiSamples=4
visual/configs/2@1280x1024_p01/configdata/ProcessorsFree=3
```

```
visual/configs/2@1280x1024_p01/pipes/0/origin/x=0
visual/configs/2@1280x1024_p01/pipes/0/origin/y=0
visual/configs/2@1280x1024_p01/pipes/0/windowed=off
visual/configs/2@1280x1024_p01/pipes/0/windowed=${$AUTO/environment/DV_WINDOWED}
visual/configs/2@1280x1024_p01/pipes/0/title=${visual/configs/title}
visual/configs/2@1280x1024_p01/pipes/0/title=${$AUTO/environment/DV_VISUAL_TITLE}

visual/configs/2@1280x1024_p01/pipes/1/origin/x=0
visual/configs/2@1280x1024_p01/pipes/1/origin/y=0
visual/configs/2@1280x1024_p01/pipes/1/windowed=off
visual/configs/2@1280x1024_p01/pipes/1/windowed=${$AUTO/environment/DV_WINDOWED}
visual/configs/2@1280x1024_p01/pipes/1/title=${visual/configs/title}
visual/configs/2@1280x1024_p01/pipes/1/title=${$AUTO/environment/DV_VISUAL_TITLE}

visual/configs/2@1280x1024_p01/views/1/pipe=0
visual/configs/2@1280x1024_p01/views/1/origin/x=0
visual/configs/2@1280x1024_p01/views/1/origin/y=0
visual/configs/2@1280x1024_p01/views/1/size/w=1280
visual/configs/2@1280x1024_p01/views/1/size/h=1024

visual/configs/2@1280x1024_p01/views/2/pipe=1
visual/configs/2@1280x1024_p01/views/2/origin/x=0
visual/configs/2@1280x1024_p01/views/2/origin/y=0
visual/configs/2@1280x1024_p01/views/2/size/w=1280
visual/configs/2@1280x1024_p01/views/2/size/h=1024

#--- nxvisor - VISUAL CONFIGURATION -------------------------------
visual/setups/nvisorsx100/config=2@1280x1024_p01
visual/setups/nvisorsx100/resources/head/views/1/projection=nvisor2/left
visual/setups/nvisorsx100/resources/head/views/2/projection=nvisor2/right

#--- nvisorsx stereo nvisor2 (100% overlap)--- 46 degrees FOV ------
visual/projections/nvisor2/left/mode=left
visual/projections/nvisor2/left/relative=head
visual/projections/nvisor2/left/size/w=1280
visual/projections/nvisor2/left/size/h=1024
visual/projections/nvisor2/left/offset/x=-10
visual/projections/nvisor2/left/offset/y=0
visual/projections/nvisor2/left/offset/z=-1507
visual/projections/nvisor2/left/orientation/x=0
visual/projections/nvisor2/left/orientation/y=0
visual/projections/nvisor2/left/orientation/z=0

visual/projections/nvisor2/right/mode=right
visual/projections/nvisor2/right/relative=head
visual/projections/nvisor2/right/size/w=1280
visual/projections/nvisor2/right/size/h=1024
visual/projections/nvisor2/right/offset/x=10
visual/projections/nvisor2/right/offset/y=0
visual/projections/nvisor2/right/offset/z=-1507
visual/projections/nvisor2/right/orientation/x=0
visual/projections/nvisor2/right/orientation/y=0
visual/projections/nvisor2/right/orientation/z=0
```

Annex III

PTC/Division Reality NIAR VRC customized body actor file



```
########################################################################
#
#  NIAR Body for Pinch Glove - Tracks both hands with collision
#       Customized by Fernando F Toledo - NIAR VR Center
#          Any modifications is not permitted without
#               previous authorization.
#
########################################################################

UNIT   m                # Working in metres.
SCALE  1.0              # Full scale.

%ifdef ROLE
ROLE "$(ROLE)"          # Define the dVISE Role.
%endif

%ifdef XDOMAIN_BODY
        SYNC ("visual", "local_64")
%else
        SYNC ("visual", "local")
%endif

BODY_FLY_CONTROL {

BIND "BUTTON_1" FLY_FORWARD_SLOW
BIND "" FLY_FORWARD_FAST
BIND "" FLY_FORWARD_ACCELERATE
FLY_FORWARD_ACCELERATION 0.075
FLY_FORWARD_SLOW_SPEED 0.25
FLY_FORWARD_FAST_SPEED 4
FLY_FORWARD_MAX_SPEED 8

BIND "BUTTON_2" FLY_BACKWARD_SLOW
BIND "" FLY_BACKWARD_FAST
BIND "" FLY_BACKWARD_ACCELERATE
FLY_BACKWARD_ACCELERATION 0.075
FLY_BACKWARD_SLOW_SPEED 0.25
FLY_BACKWARD_FAST_SPEED 4
FLY_BACKWARD_MAX_SPEED 8

BIND "BUTTON_7" FLY_LEFT_SLOW
BIND "" FLY_LEFT_FAST
BIND "" FLY_LEFT_ACCELERATE
FLY_LEFT_ACCELERATION 0.075
FLY_LEFT_SLOW_SPEED 0.25
FLY_LEFT_FAST_SPEED 4
FLY_LEFT_MAX_SPEED 8

BIND "BUTTON_8" FLY_RIGHT_SLOW
BIND "" FLY_RIGHT_FAST
BIND "" FLY_RIGHT_ACCELERATE
FLY_RIGHT_ACCELERATION 0.075
FLY_RIGHT_SLOW_SPEED 0.25
FLY_RIGHT_FAST_SPEED 4
FLY_RIGHT_MAX_SPEED 8

BIND "BUTTON_5" FLY_UP_SLOW
BIND "" FLY_UP_FAST
BIND "" FLY_UP_ACCELERATE
FLY_UP_ACCELERATION 0.075
FLY_UP_SLOW_SPEED 0.25
FLY_UP_FAST_SPEED 4
FLY_UP_MAX_SPEED 8
```

```
BIND "BUTTON_6" FLY_DOWN_SLOW
BIND "" FLY_DOWN_FAST
BIND "" FLY_DOWN_ACCELERATE
FLY_DOWN_ACCELERATION 0.075
FLY_DOWN_SLOW_SPEED 0.25
FLY_DOWN_FAST_SPEED 4
FLY_DOWN_MAX_SPEED 8

BIND "BUTTON_10" ROT_LEFT_SLOW
BIND "" ROT_LEFT_FAST
BIND "" ROT_LEFT_ACCELERATE
ROT_LEFT_ACCELERATION 1
ROT_LEFT_SLOW_SPEED 10
ROT_LEFT_FAST_SPEED 30
ROT_LEFT_MAX_SPEED 300

BIND "BUTTON_11" ROT_RIGHT_SLOW
BIND "" ROT_RIGHT_FAST
BIND "" ROT_RIGHT_ACCELERATE
ROT_RIGHT_ACCELERATION 1
ROT_RIGHT_SLOW_SPEED 10
ROT_RIGHT_FAST_SPEED 30
ROT_RIGHT_MAX_SPEED 300

BIND "BUTTON_13" ROT_UP_SLOW
BIND "" ROT_UP_FAST
BIND "" ROT_UP_ACCELERATE
ROT_UP_ACCELERATION 1
ROT_UP_SLOW_SPEED 10
ROT_UP_FAST_SPEED 30
ROT_UP_MAX_SPEED 300

BIND "BUTTON_14" ROT_DOWN_SLOW
BIND "" ROT_DOWN_FAST
BIND "" ROT_DOWN_ACCELERATE
ROT_DOWN_ACCELERATION 1
ROT_DOWN_SLOW_SPEED 10
ROT_DOWN_FAST_SPEED 30
ROT_DOWN_MAX_SPEED 300

BIND "BUTTON_4" FLY_VERTICAL

VERTICAL_FLY_MODE on
ALT_FLY_MODE on
FLY_FORWARD on
FLY_FORWARD_ACCELERATE on
FLY_BACKWARD on
FLY_BACKWARD_ACCELERATE on
FLY_LEFT on
FLY_LEFT_ACCELERATE on
FLY_RIGHT on
FLY_RIGHT_ACCELERATE on
FLY_UP on
FLY_UP_ACCELERATE on
FLY_DOWN on
FLY_DOWN_ACCELERATE on

ROT_LEFT on
ROT_LEFT_ACCELERATE on
ROT_RIGHT on
ROT_RIGHT_ACCELERATE on
ROT_UP on
ROT_UP_ACCELERATE on
ROT_DOWN on
ROT_DOWN_ACCELERATE on
}

#
# Define the hierarchy of the body.
#
```

```
BODY
{
    head {
%ifdef DV_FULL_BODY
#        VISUAL "body/body1/newhead" {
#            VECTORINTERSECT OFF
#                                   }
%endif
       COLLIDE {
        }
        RESOURCE audio {
            GAIN 200
                      }
        eyes {
            RESOURCE visual {
                              %ifdef XDOMAIN_BODY
                                     NAME "local_64/head"
                              %else
                                     NAME "local/head"
                              %endif
                              }
               }
%ifdef GUI_TRACKER
        RESOURCE sensor {
            NAME "local/dviseguiHead"
                       }
%else
        RESOURCE sensor {
            NAME "local/head"
                       }
%endif
        SCREEN_INTERSECT{
                        %ifdef XDOMAIN_BODY
                              PIPENAME "local_64/0"
                        %endif
                       }
        RESOURCE input {
            NAME "local/head"
                      }
        RESOURCE input {
            NAME "local/hand"
                      }
%ifdef DV_FULL_BODY
        torso {
            ALIGN_PARENT
#            visual "body/body1/torso" {
#                VECTORINTERSECT OFF
#                                      }
            rightUpperArm {
                POSITION (0.23, -0.19, 0)
                ORIENTATION (-94, 0, 0)
                visual "body/body1/rtop" {
                    VECTORINTERSECT OFF
                                        }
                rightForeArm {
                    POSITION (0, 0, -0.313)
                    ORIENTATION (8, 0, 0)
                    visual "body/body1/rfore" {
                        VECTORINTERSECT OFF
                                             }
                              }
                          }
            leftUpperArm {
                POSITION (-0.23, -0.19, 0)
                ORIENTATION (-94, 0, 0)
                visual "body/body1/ltop" {
                    VECTORINTERSECT OFF
                                        }
                leftForeArm {
```

```
                    POSITION (0, 0, -0.313)
                    ORIENTATION (8, 0, 0)
                    visual "body/body1/lfore" {
                        VECTORINTERSECT OFF
                                                  }
                          }
                        }
               }
%endif
    }
     leftHand {
        POSITION (-0.23, -0.865, -0.03)
        ORIENTATION (-80, 0, 0)
%ifdef DV_FULL_BODY
        leftWrist {
            POSITION (-0.015, -0.02, 0.043)
            INVERSE_KINEMATICS leftForeArm 0.313 0.33
        }
%endif
        RESOURCE sensor {
            NAME "local/leftHand"
        }
        RESOURCE input {
            NAME "local/leftHand"
        }
        COLLIDE {
            PICKING
        }
        VISUAL "body/lhand" {
            VECTORINTERSECT ON
        }
    }
    rightHand {
        POSITION (0.23, -0.865, -0.03)
        ORIENTATION (-80, 0, 0)
%ifdef DV_FULL_BODY
        rightWrist {
            POSITION (0.015, -0.02, 0.043)
            INVERSE_KINEMATICS rightForeArm 0.313 0.33
        }
%endif
        RESOURCE sensor {
            NAME "local/rightHand"
        }
        RESOURCE input {
            NAME "local/rightHand"
        }
        COLLIDE {
            PICKING
        }
        VISUAL "body/rhand" {
            VECTORINTERSECT ON
        }
    }
}

# End of BODY
```