Hamburg Bit-Bots
Wolfgang OP
Jasper Güldenstein
Real World Wolfgang OP

- 20 DOF Humanoid Robot
- Descendant of the Nimbro OP
- 3D printed elastic elements
- Parallel Elastic Actuator (PEA) in the knees
- Focus on robustness
- 715 Hz Control loop

Publications
- Wolfgang-OP: A Robust Humanoid Robot Platform for Research and Competitions (Humanoids 2021)
Wolfgang OP Simulation Model

- Fully Open Source
- Modeled after real robot
  - Actuators
  - PEA
  - IMUs
  - Force Sensors
- Onshape → URDF → PROTO
  - Accurate physical properties
- Full Bounding Objects collision
Wolfgang OP Simulation Model

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Contributions to the league

● Strong involvement in model specifications
● 2 tools for creating collision models
  – Manual 3D model → Bounding object
  – Automatic rotated bounding boxes
● Several contributions to urdf2webots
Robot Model - Team Sweaty
Contribution for the Best Robot Model Award in RoboCup 2021
Coupling Mechanism for high torque and low backlash

Back view of Sweaty’s hip. Coupling Mechanisms are used for pitch and roll.

Joint Mechanism for Knee, Ankle and lower Back

Robot Model - Team Sweaty

Linear Motor combined with multiple Hinge Joint with Backlash → Simulation time 0.1
Hinge Joint with Backlash and a Rotational Motor → Simulation time 1.0
Modeling of the HingeJointWithBacklash and the RotationalMotor
MRL-HSL Robot

• Avoiding Complexity
  Simplification of the parts
  Using geometric shapes as bounding object
  Removing unnecessary components

• Accuracy
  Validated physical characteristics
  Optimum bounding objects
  Perfect physical Collision

• Appearance
Robot Model Competition

RoboFEI
Starting with the basics...
Topology Optimization process
Colmeias (hives)
Some difficulties... 😊
01. RFC Robot Model Vision
The Mickey Plattform Gen 2021

OVERVIEW
- 32 DoF
- Height = 1 m
- Weight = 6 kg
- Shoe size = 25 EU
- Customizable hairstyles
- Costs below 2000 €

SMART ACTUATORS
- Custom electronics
- 8 motors connected to one servo board
- 60 € per board
- Gear boxes from RC servos
- Current controlled 5 A motor drivers
- Sophisticated motor control loops

GOAL
- Cost reduction
- 3D printed
- Custom smart actuators
- Indirectly driven joints

WEBOTS CHALLENGES
- 32 DoF
- Custom smart actuators
- Loopy structures
- No arms
- Missing hair physics

3D PRINT
- Based on premade robot model integrated our needs
- FDM printable
- Prints fit on 22*22 cm² build plate
- Printed on cheap private 3d printer

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Reproduction of the real environment

Implementation of closed links
Implemented a closed link mechanism to reproduce the symmetric behavior of a real robot.

Motor characteristic experiment
To use Kondo’s B3M series servo motors, we conducted a unique experiment using powder brakes. By using the values obtained in the experiment, we were able to reproduce accurate motion closer to real use than the nominal values.

Reduced computational load
Simplifying the bounding box
The bounding box consists of the minimum required to simulate the model. The total is 20, which can reduce the computational load of the model.

Reduction of polygons
To simplify the model, we filled all hole shapes, used Autodesk Inventor’s feature Shrinkwrap, replaced complicated forms with the cuboid, removed parts that are not related to movement.
HERoEHS Robot Model Presentation

RoboCup 2021
Virtual Humanoid Soccer Competition
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I. Specification of ALICE

II. Design of ALICE

III. Mechanical features of ALICE

IV. Proto model of ALICE
I. Specification of ALICE

- Robot name: ALICE 3
- Degrees of freedom: 22 DOF
- Height of robot: 133 cm
- Weight of robot: 24.6 kg
- Type of motors:
  - Robotis Dynamixel XH540-V270-R
  - Robotis Dynamixel Pro PH42-020-S300-R
  - Robotis Dynamixel Pro PH54-100-S500-R
I. Specification of ALICE

### Computing Units

- NVIDIA Jetson AGX Xavier 32GB
- Intel NUC 10\(^{th}\) Core i5

### Type of Sensors

- ZED stereo camera (It replace RGB cameras in webot)
- LORD IMU sensor (It separate Gyro and Accelerometer in webot)
- ROBOTOUS Force-Torque 6-axis sensors (It don't use Torque 3-axis in webot)
- SingleTact FSR CAL 15MM DIAMETER, 450N/100LB FORCE (It just use in webot)
Ⅱ. Design of ALICE

ALICE Design Philosophy

- Female-type design determined through preliminary survey.
- A moderately human-like design that doesn't fall into Uncanny Valley.
- Implementing human-like curved design.
- A height of about 130cm that an adult person can look down on while feeling psychologically comfortable.

ALICE is designed to be a human-friendly robot.
Ⅱ. Design of ALICE

- It can be held easily by the handler in an emergency.
- It protects the computing units from direct collision.
Ⅲ. Mechanical features of ALICE

Axial alignment and overcoming spatial constraints

- Using bevel gears to make legs slimmer.
- Using a gear train to align the two rotation axes at the ankle joint.
- Using a gear train to align the three rotation axes at the hip joint.
III. Mechanical features of ALICE

- Standing up motion using the waist pitch joint
  - ALICE can stand up using the waist pitch joint like a human does.

- Searching motion using the waist yaw joint
  - ALICE can search widely and fast by using the waist yaw joint.
Ⅲ. Mechanical features of ALICE

Curved legs for ROM expansion
- It can move 80 degrees forward and 100 degrees backward.

Foot design features
- It is designed as wide as possible to increase the ZMP space.
- A lot of pockets make the feet light weight.
- Designed with a thin vertical frame to adapt well to soft grass.
IV. Proto model of ALICE

- Fully implemented visual model and beautiful coloring.
- A low-complexity collision model using geometric primitives.
- Reliable base pose preset by PROTO.
감사합니다
Thank you
Overview

RoboCup Worldwide 2021 was held virtually in simulation. As a participant, the NUbots team from the University of Newcastle created a virtual model of the NUbots platform for the Webots Simulation Environment. The process of converting the physical model to a virtual model required modifications to various parameters and values, to match the operation of the virtual model to the physical one in the real world as close as possible.

Mesh Implementation

To generate the mesh and define physical descriptions such as the mass and joints of the NUbots platform, the NUbots URDF was converted to a Webots PROTO file using the urdf2webots utility [1]. The NUbots URDF file is based upon the robot developed by the University of Bonn in collaboration with the German company igus® GmbH in 2015 [2].

To improve simulation performance, the collision boxes of the virtual model were constructed from Webots geometric primitives. These bounding boxes maintain the general structure of the NUbots model and ensure all joints still have their full range of motion.

Accelerometer and Gyroscope

Webots accelerometer and gyroscope sensor nodes are used to model the NUbots robot. Both simulated devices are modified to represent the LIS331DLH [3] and L3G4200D [4] devices respectively, to a satisfactory level of accuracy. The adjustable parameters of the accelerometer and gyroscope sensor nodes are modified to match the physical NUbots platform.

The resolution of the accelerometer and gyroscope is calculated by:

\[
\text{resolution} = \frac{\text{size of range}}{4095}
\]

LUT for Accelerometer

<table>
<thead>
<tr>
<th>Measured Value [m/s²]</th>
<th>Return Value [m/s²]</th>
<th>Noise [Hz]</th>
</tr>
</thead>
<tbody>
<tr>
<td>-39.24</td>
<td>60.76</td>
<td>0.000704</td>
</tr>
<tr>
<td>39.24</td>
<td>139.24</td>
<td>0.000307</td>
</tr>
</tbody>
</table>

LUT for Gyroscope

<table>
<thead>
<tr>
<th>Measured Value [rad/s]</th>
<th>Return Value [rad/s]</th>
<th>Noise [Hz]</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.72665</td>
<td>91.238</td>
<td>0.0001151</td>
</tr>
<tr>
<td>0.72665</td>
<td>108.72</td>
<td>0.00096541</td>
</tr>
</tbody>
</table>

A lookup table (LUT) is used to indicate how values measured by Webots are mapped to values returned by the sensor.

Noise values are calculated using the following equation for both sensors.

\[
\text{noise min} = \frac{\text{stddev}}{\text{min} + DC \text{ offset}}
\]

\[
\text{noise max} = \frac{\text{stddev}}{\text{max} + DC \text{ offset}}
\]

Motor Implementation

The arms and head of the NUbots robot use Dynamixel MX64AR servos, with two in each shoulder, one in each elbow, and two in the neck. The legs use Dynamixel MX106 servos, with two in each ankle, three in each hip, and one in each knee.

In Webots, all the active joints are implemented using HingeJointWithBacklash. The backlash parameter supplied in the Dynamixel data sheet is 0.33° (approx. 0.0058 [rad]). However, a value of 0.01 [rad] was used, due to the limitations of modelling small backlash values in Webots.

As the physical NUbots robot operates at roughly 14v, the voltage parameters for the Dynamixel motors are set to 14.8v in Webots.

Camera Implementation

In the physical robot, there are two FLIR BlackFly S BFS-US-13Y3C-C cameras [5] with Lensagon BF10M1928S118C lenses [6]. Due to the lack of full spherical lens support in Webots, the lenses are implemented with rectilinear projection.

The field of view is reduced to $\frac{\pi}{2}$ since the rectilinear lens cannot support a field of view of more than $\frac{\pi}{2}$ and values between these had an undesirable zoom effect.

The resolution of the cameras is 640x480px. On the physical robot the resolution is 1280x1024px, however this value was lowered due bandwidth limitations.

Noise has been set to 1e-9 as there is little noise on the physical cameras. Motion blur is set to 10, as the physical cameras run at 100fps, with very little motion blur. Since rectilinear projection is being used, the spherical field and lens parameters are set to their defaults. The lens of the real camera has a fixed focus, so focus parameters are left at their default values. The focal length is set to 1.98mm, the focal length of the physical cameras.

References


HumanoidOpenPlatform


http://softwareservices.flir.com/FLIR:BFS-U3-13Y3C-C.Htm


https://www.lensation.de/pdf/BF10M1928S118C.pdf
SAHR
(Starkit Autonomous Humanoid Robot)
Origin

SolidWorks -> URDF -> Proto
OnShape model
Simplifying hands
Simplifying head
Bounding Objects
Power

No emergency button
PowerBoard
Battery

Almost 6% of robot weight
Servos

8 Dynamixel MX64-AT (head, arms)
12 Dynamixel MX106-T (legs, shoulders)

Voltage 14.8V
DXLBoard

Accelerometer (MPU-6050), Gyro (MPU-6050), Change sensor range inside the proto, PCB texture :)
ForceFoot

8 touch sensors (HL-703 Strain gauge with HX711 ADC)

Redesign of Rhoban ForceFoot (add 3d printed cover)
Cameras

Stereo pair of 2 FLIR BlackFly S
resolution: 1440x1080 720x540
Wideangle cameras (1.762 FOV)
Lens:
  center 0.5 0.5
  radialCoefficients -0.26 -0.26
  tangentialCoefficients 0 0
Materials

Brushed aluminum, Carbon fiber, Plastic