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Automated Optimisation of Collision-aware Contact Classification in Robotics

Introduction

- Robots have become an essential part of our everyday lives.
- Humanoid robots are designed to take over simple human tasks to collaborate with humans, or assist in extreme environments [1].
- To improve their autonomy, these robots have to be able to discriminate unintended collisions from intended contact.

Solution:

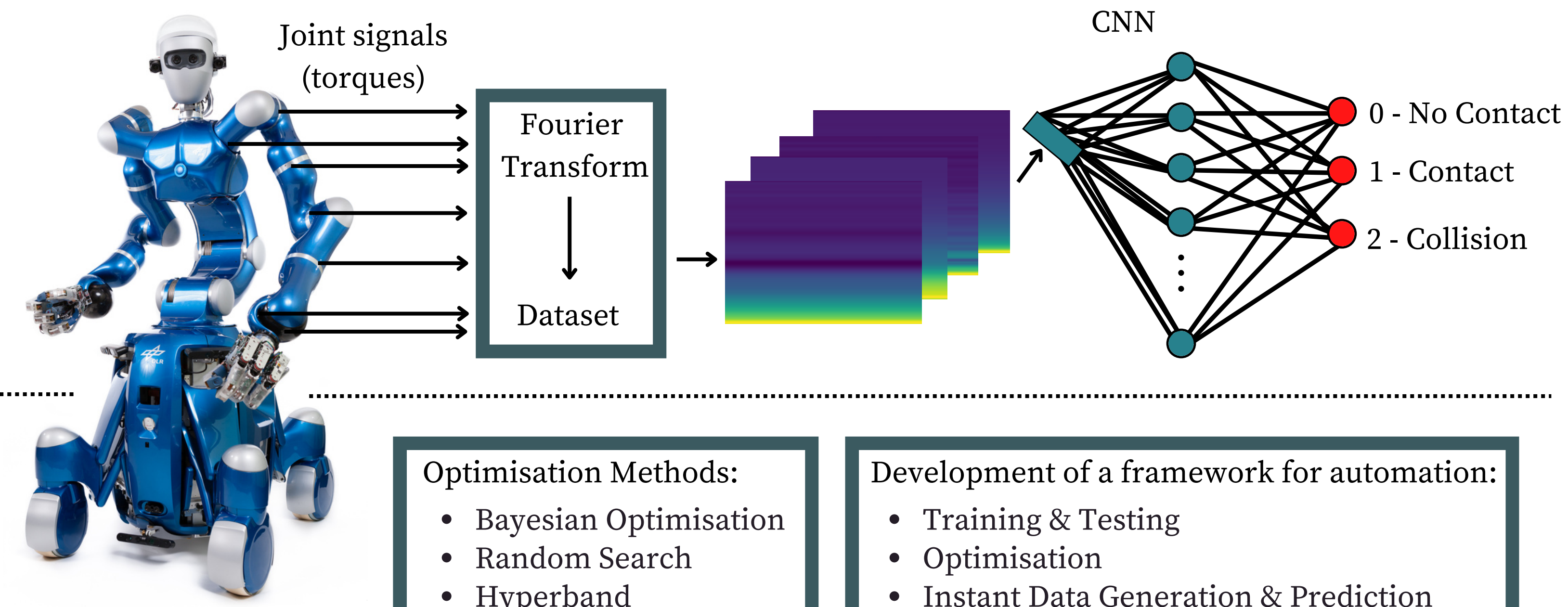
➤ **Collision-aware Contact Classifier**

Related Work

- The state-of-the-art collision detection on humanoid robots suggests setting up specific constant thresholds.
- Once a measured torque signal from the robot surpasses the threshold, it can be classified as a collision [2].
- However, this approach is tedious and not prone to changes.
- Creating a **state-of-the-art collision classifier** using grayscale thresholds, only a maximum of **68.7% recognition accuracy** is achieved.

➤ Hence, by implementing a convolutional neural network (CNN), that reads torques from the robot and applies Fourier Transform (FT), a new classifier is introduced.

Methodology



Rollin' Justin (DLR)

Optimisation Methods:

- Bayesian Optimisation
- Random Search
- Hyperband

Development of a framework for automation:

- Training & Testing
- Optimisation
- Instant Data Generation & Prediction

Results

The best average recognition accuracies achieved by the classifier

68.7% State-of-the-art classifier

72% Manual Optimisation of the CNN (Base Accuracy)

Automated Optimisation of the collision-aware contact classifier:

97.6% Bayesian Optimisation

98% Hyperband Optimisation

98.1% Random Search Optimisation

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Conclusion

1. By implementing a CNN and FT, the collision-aware contact classifier's recognition accuracy has been improved significantly.
2. Optimisation is important in order to achieve better results that lead to safer work environments.
3. The framework offers a complex infrastructure that allows future extensions of the classifier.

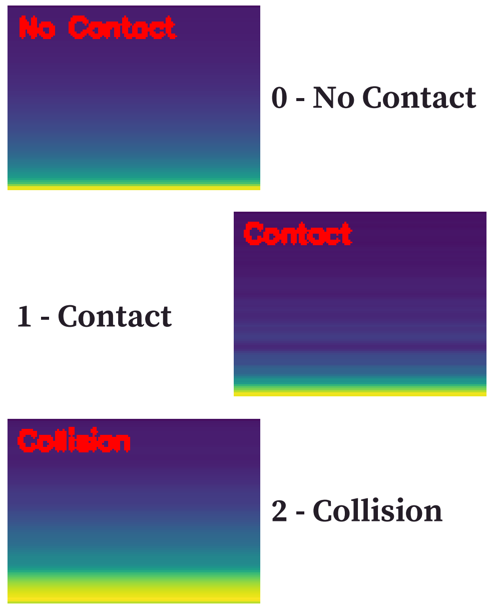
Future Work

- Add a new contact state: **Contact + Collision**
- Increase the dataset for the training and testing procedures
- Decrease the prediction time to let the robot react more quickly to collisions
- Create collision-aware contact classifiers for each joint and each action of the robot to be more precise [3]

Analysis

- The recognition accuracy has been **improved** by **+29.4%**
- The **3** contact states: **No Contact, Contact, Collision** can be successfully classified using a CNN and spectrograms (images from the FT)
- The framework automates the **5** most important processes
- Through the framework, the classifier can be **used on any robot and any joint**

Predictions



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