# Bearing Defect Simulation Library

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## 1 Team members

I will be the only person working on this project.

## 2 Introduction

Rolling element bearings are an indispensable component of numerous industrial machines. Their role is to reduce the friction forces between two parts in motion, one relative to another. Consequently, they are subject to considerable forces and high rotational speed. In this regard, they constitute an essential element and a critical source of failure, as an example, 50% of electrical motors failures are due to bearing failures [3].

Certainly, bearing defect identification is very well studied, and many techniques have been developed to recognize defects in bearings. The most common ones use vibration data from microphones or accelerometers. Indeed, when a defect appears in a bearing, its vibration signature change, these sensors can detect it.

A typical publication on this topic will present a new bearing defect identification method and then validate the method on two datasets. The first one is a simple simulation of bearing defect frequencies with some white noise added, and the second dataset using artificially damaged bearing on a test bench.

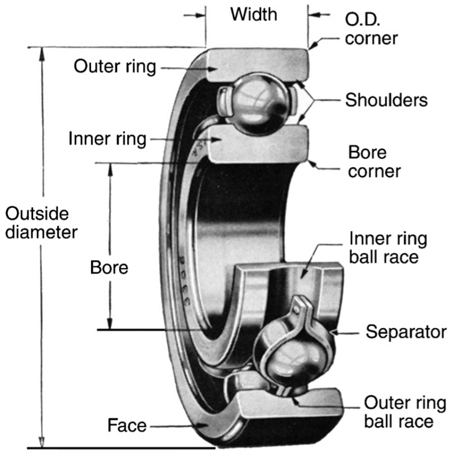
However, in an industrial application, bearing vibration signals are much noisier and contain more vibration harmonics from other machines functioning around the bearing. Consequently, the procedure used in the literature tends to validate techniques that give poor results in the real-life application. This project aims to find a new way to simulate bearing defects that is more accurate to evaluate bearing defect identification methods.

In the following, standard bearing components are presented and the possible defect that can grow on it; this constitutes the system under investigation (SUI) for this project. Then the goal of the project is explained more in detail.

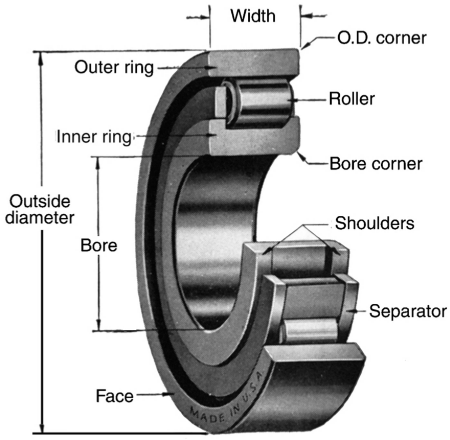
## 3 Bearing defect presentation

### 3.1 Bearing

Rolling element bearings are composed of 4 parts: an inner race, an outer race, some rolling elements (balls or rollers), and a cage that holds the rolling elements apart from one another. Figure 1 [2] presents those different parts in a rolling element bearing.




(a) Ball bearing

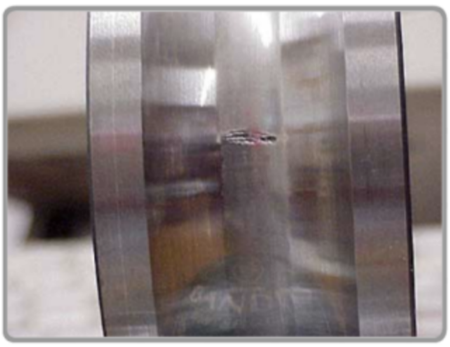



(b) Straight rollers bearing

Figure 1: Components of rolling elements bearings

## 3.2 Bearing defects

Any part of the bearing can wear out and eventually crack; the most common defects are located on the race as they are the most solicited components. Figure 2 [1] shows a defect on the outer race and a defect on the inner race. The passage of the rolling element on the defects generates an impulse that can be identified in the vibration signal.



(a) Inner-race fault

(b) Outer-race fault

Figure 2: Race defects.

## 3.3 Bearing defect simulation

The simplest way to simulate bearing defect is to calculate the theoretical passage frequency of any rolling element on a given point of a race. These frequencies formula only depend on the rotation speed of the bearing and its geometric configuration. This signal is then mixed with some noise to create a waveform. More advanced methods consider the passage frequency and consider the defect's geometrical shape to obtain a more realistic waveform. However, there is very little work on more complex bearing defect shapes.

## 4 Goal and deliverable of the project

This project aims to address this limitation by simulating a more complex defect shape and would be a great tool to evaluate bearing defect identification methods. It is proposed to deliver a python library to generate a simulated vibration signal for different bearing configurations.

## References

[1] Mobius institute - rolling element bearings. Mobius institute website.

[2] Michael M. Khonsari and E. Richard Booser. *Applied Tribology Bearing Design and Lubrication*. John Wiley & Sons, 2008.

[3] S. Nandi, H. A. Toliyat, and X. Li. Condition monitoring and fault diagnosis of electrical motors—a review. *IEEE Transactions on Energy Conversion*, 20(4):719–729, 2005.