# Philip Morris: Data Analysis Improvement of Ciliary Beating of 3D Epithelial Tissue

# Final report

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# 1 Project Description

## 1.1 Project Context

Philip Morris International (PMI) is a global cigarette and tobacco company with headquarters in Lausanne. The research and development program of PMI focuses on the development of products with the potential to reduce the risk of tobacco related diseases. To this end, new products are tested against ordinary cigarettes by exposing human tissue cultures to smoke or aerosol of both products. The effect of the exposure is then analysed by observing different features of the tissue, one of which is the ciliary beating.

## 1.2 Goals and Objectives of the Project

The goal of this project is to implement a tool for the automatic analysis of ciliary beating in tissue movies. Concretely the objectives are the following:

- Allowing batch processing of video-data contained in a folder (including subfolders).
- Pre-processing of the video data in order to remove noise by smoothing with a customisable 3D kernel.
- Scoring the tissue surface activity using simple descriptive statistics and storing the results in an activity image.
- Determining the frequency distribution given per region of interest (ROI) and extracting the dominant frequency.
- Processing should be possible on multiple scales, i.e. ROI of variable size.
- Illustrating the phase of the beating frequency.

Part of the project is also an evaluation of the performance of different techniques applied to the problem and other research objectives such as:

- Evaluating the effect of the ROI size on performance.
- Evaluating the probable shape of the beating pattern on a by beating movie basis.
- Comparing different techniques for the frequency analysis (e.g. FFT and wavelet transform).

Given the scope of this project and the relatively large amount of objectives, it should be noted that some of the objectives have been given a higher priority than others. The ultimate goal of this project is to provide a tool for frequency analysis and task-priorities were therefore weighted with this goal in mind. This means for example that de-noising, a whole subject on it's own, has not be studied and evaluated as extensively as techniques for frequency analysis.

# 2 Methodology

The implementation of the tool was carried out in Matlab. The decision to use Matlab has been taken in agreement with the client and is based on the ease of handling image and video processing and the relatively fast development time that Matlab provides. Git has been used as version control tool.
Development has been done in an incremental and iterative fashion roughly following the SCRUM framework. The objectives have been distributed across sprints of two weeks each. To keep track of the progress and help manage the project we have been using Taiga, an open source project management platform similar to JIRA. Both the client and project stakeholders were given access to Taiga and have been able to follow the progress.
Testing of our implementation using synthetic test-data has been an integral part of the development process to ensure correctness of the implementation. In order to maintain a high code-quality, code reviews by the other respective developer have been performed for every task.

## 2.1 State of the art

The arguably most accurate method for analysing the ciliary beating frequency is the direct measurement from high-speed video recordings. This is of course very time-consuming and therefore several automated methods have been proposed. The most commonly used approaches for the automated analysis of ciliary beating are based on using the Fast Fourier Transform (FFT) to analyse intensity-signals in a region of interest and has been the principal approach and starting point for further exploration used in this project. Other methods such as photomultiplier and modified photodiode techniques rely on different hardware and inputs and are therefore not considered.

# 3 Realisation

# 4 Results

Analysis of the tool, such as

- effect of ROI size on performance;
- time consumption of the different techniques;
- comparison of performance with different parameters (denoising, ...).

# 5 Recommendations

## 5.1 Statement of Recommendations

## 5.2 Limitations

## 5.3 Outstanding Issues and Perspective for Future Work

# 6 [Other relevant section]