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PEFAP : Estimating the environmental footprint of food products from packaging data

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Summary

Food consumption represents an important part of our ecological footprint (Sala et al., 2019), therefore changes in food consumption habits can greatly help to mitigate it. In order to help consumers to make more informed food consumption choices, several ecolabelling initiatives have been developed recently by institutional and private actors (ADEME, 2020a). Most of these initiatives use a single environmental impact value for a given product type. This default value is constructed from a recipe (i.e. proportion of ingredients), a processing chain, and a supply chain that is considered an "average" scenario.This approach appears to be frugal in terms of data, but it is obviously limited. It does not allow for differentiation of products within a category. PEFAP (Product Environmental Footprint According to Packaging data) aims to fill this gap.It estimates the most likely impact for each product individually, based on the information on the packaging (ordered list of ingredients and nutritional composition) and the environmental impacts of the agricultural production of the ingredients. To the best of our knowledge, there is no such software available, whether open source or not. The users of this software are multiple: it allows researchers to assign environmental impacts to commercially available food products in environmental studies, but also as additional criteria in economic or nutritional studies. It allows actors in the food industry to automate and reduce the cost of calculating the impact of their products. It also offers the opportunity to third parties, such as independent organisations and consumer applications, to display an estimate of the environmental footprint of their products.

Statement of need

To calculate a product footprint, PEFAP needs: - The list of ingredients and the nutritional values from the product packaging. This can be provided as Python objects or by indicating the barcode of a food product, the open Food Facts database is then used to obtain this data. This is the only information that the user needs to fill in specifically for a given product. - Environmental footprint and nutrient composition databases for ingredients. The Agribalyse (ADEME, 2020b) and Ciqual (ANSES, 2020) databases are used because of their scope and availability.

Functionality

The algorithm used by this program is based on a Monte-Carlo approach to estimate the impact of a product. Its principle is to pick random possible recipes of the product with proportions

that are consistent with the partial information in the ingredient list and whose combination corresponds to the displayed nutritional data (without deviating too substantially). The convergence is achieved by the stabilization of the geometric mean of the runs within a given confidence interval. The sampling of possible recipes is made as accurate as possible by using a nonlinear optimization solver (Gamrath et al., 2020), and Optimization-Based Bound Tightening to deduce the ranges of possible values of the mass of each ingredient respecting the nutritional constraints of the system. A more extensive explanation of the principles used is available in the documentation.

This program features a class based implementation of the impact estimation algorithm that can be integrated in Python projects. It also integrates a reporting tool to create HTML and PDF impact estimation reports of a product. To be functional, this program has been interfaced to the Open Food Facts database (Open Food Facts, n.d.) providing packaging information. It uses data from the Ciqual (ANSES, 2020) and FCEN (Santé Canada, 2015) nutritional databases, and the Agribalyse (ADEME, 2020b) environmental impact database. All these data are freely available and fit to a French context, but it could be easily adapted to other data sources.

Example

The code sample below shows a simple example of getting a product from the Open Food Facts database, computing its Environmental Footprint and climate change impacts, and finally creating a HTML report of the result.

```
from impacts_estimation import estimate_impacts
from openfoodfacts import get_product
from reporting import ProductImpactReport

product = get_product(barcode='3175681790285')['product']

impact_categories = ['EF single score',
                     'Climate change']
impact_estimation_result = estimate_impacts(product=product,
                                            impact_names=impact_categories)

for impact_category in impact_categories:
    print(f"{impact_category}: "
          f"{impact_estimation_result['impacts_geom_means'][impact_category]:.4} "
          f"{impact_estimation_result['impacts_units'][impact_category]}")
# EF single score: 0.03832 mPt
# Climate change: 0.3819 kg CO2 eq


# Generating an impact estimation report
reporter = ProductImpactReport(product=product)

reporter.to_html()
```

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