# Helping to Make Potatoes Future-Proof With Applied Mathematics

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# Outline

- 2014: Meeting HZPC company at SWI-2014
- 2016: Potato Valley initiative
- 2017: Student projects
- 2018: "Vitality" project
- Lessons learned and the future

# It all started with HZPC problem at SWI-2014

# Cutting potatoes into french fries (mathematically)

**Problem (HZPC):** Given limited and approximate information about the size of a tuber and the volume distribution of quality parameters find:

1. how many fries of a given cross-section can be made from it
2. what is the length distribution of these fries
3. how much waste there will be
4. texture quality of the fries
5. $\Rightarrow$ predict the market value of a potato crop

# HZPC company



- Main focus: seed potatoes
- 370 employees, 800 growers, 55 breeders, 19 locations worldwide
- Market segments: traditional (potatoes sold at the daily markets), retail (supermarkets), french fries (yield security, quality consistency), peeled, crisps (high dry matter content, low sugar, consistent texture), organic (worldwide supply network)

# TU Delft SWI solution: the Finite Fry Method (FFM)

1. Given the desired width of a fry: $h = 6, 7, 8, \ldots, 16$ mm
2. Introduce a uniform grid in the $(x, y)$-plane with step $h$ in each direction
3. Vertical discretization is uniform with step $L/10$
4. Piecewise linear approximation of the potato surface
5. Detect all fries by computing the intersection of fry elements with the surface
6. Discard fries that are too thin or too short
7. Output: virtual fries, length distribution, waste

# Cutting tubers into fries (virtually)
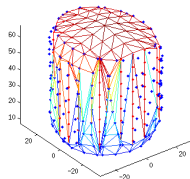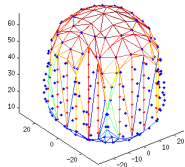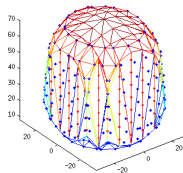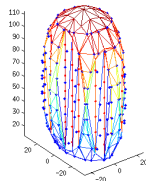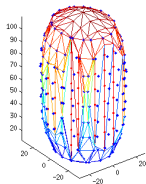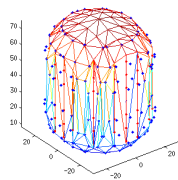
# Distributions of lengths and waste
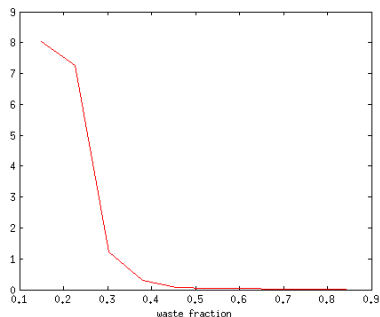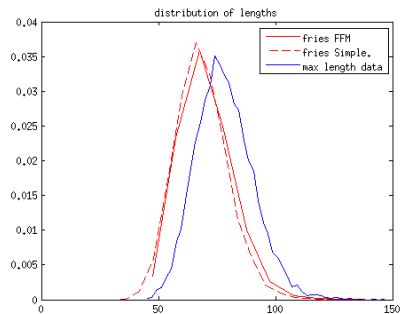


The code is now being used by HZPC customers

# 2015–2016: keeping in touch

# Dutch launch 'Potato Valley'



In the north of the Netherlands, farmers and researchers have joined forces in a new platform to future-proof the potato. The alliance, named 'Potato Valley', targets the 800 potato growers in Groningen and Friesland. Most of these are seed potato growers, but potatoes for consumption and the food industry will also come on board, broadcaster NOS said. In particular, more research into disease and crop protection is necessary, LTO Noord spokeswoman, Tineke de Vries, told RTV Noord. The Dutch eat around 2.5 billion kilos of potatoes a year – or 140 kilos for every man, woman and child – and export a further one billion kilos. 'Valley', after Silicon Valley, is a popular term in the Netherlands to describe innovation initiatives. For example, the Food Valley is a centre for food research near Wageningen, and Drunen has a Metal Valley which is supposed to turn the Noord-Brabant town into an 'innovative focal point' for the metal and engineering sectors. Read more at www.dutchnews.nl

# 2017–2018: student projects, maintaining reputation

- Currently one MSc student and three BSc students are working on HZPC problems at the group of Numerical Analysis
- Applying PDE's (active contour method, gradient vector flow, etc.) to locate and analyze tuber cells in microscopic images
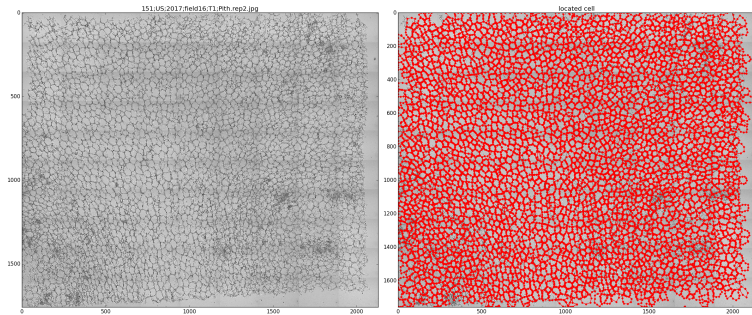
# 2016–2017: identifying interesting problem



Focusing on the early
stages: from planting to
emergence

# "Vitality" project

- Not all planted potatoes emerge 'on time', some do not emerge at all
- How do the early stages of potato development reflect the future plant vitality?
- What are the main environmental and genetic factors influencing vitality and how to control them?
- How to test potato seeds for vitality (similar to the germination test)?
- Can we issue a guarantee certificate for a batch of potato seeds?

# 2016–2017: looking for financing beyond NWO/STW

# 2018: "Vitality" project approved!

- Two PhD positions (TUD), equipment, experiments
- Practical challenges:
  1. Analysis and modeling of phenotypical data: seed tuber parameters, storage conditions, pathogens, soil, fertilizers, weather, climate, sprouting and emergence dynamics, multi-spectral drone observations.
  2. Genotype-to-Phenotype mapping: SNP association, potato-race-specific characteristics, identification of breeding targets
- Mathematical challenges:
  1. Stochastic dynamic growth models (prediction of emergence time distribution)
  2. Reduced-order data models preserving biologically relevant information
  3. Linear and nonlinear ill-posed underdetermined genetic association models (sparse coding)