#### Zero Hunger Lab

Part of the Tilburg School of Economics and Management, The Netherlands

Young Peace Makers meeting March 8, 2021



**Understanding Society** 

#### Background of people at Zero Hunger Lab





We love math



We love big data

We love to help people with our knowledge



### What are the benefits of using analytics?

#### You can save a lot of

**MONEY** (by working smarter or less investment)



## You can get a lot of insight (in models you can easily play with scenarios)



## You find all kinds of (spurious) correlations







#### You can save lives

(delivering more food, deliver it faster, better cancer treatment)





#### How is this done?

## Large amounts of data (big data)



#### **Computer power**



$$Max \quad z = \sum_{j=1}^{n} c_{j} x_{j}$$
  
Constraint 
$$\sum_{j=1}^{n} a_{ij} x_{j} \le b_{i}$$
$$x_{j} \ge 0$$









#### What happens in an Internet minute?

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#### Memory is not the issue

Memory cost per Gb:

1990	\$10.000,00		
2000	\$	10,00	
2010	\$	0,10	

2020 \$ <0,01

RICE	Rice	Rice - Brokens 5%	5% BROKEN RICE	Rice (white)	RICE, POLISHED
PEAS	Split Peas	Split Peas - Yellow	SPLIT YELLOW PEAS	Peas (yellow, split)	PEAS, DRIED, SPLIT
MAIZE	Maize	Maize - Yellow	YELLOW MAIZE	Maize (yellow)	MAIZE GRAIN, YELLOW
MAIZE	Maize	Maize - White	WHITE MAIZE	Maize (white)	MAIZE GRAIN, WHITE
BEANS	Beans	Beans - White	WHITE BEANS	Beans (white)	BEANS, WHITE

#### $\rightarrow$ Lack of standardization makes it difficult to use data





#### Computer power is increasing



SOURCE: RAY KURZWEIL, "THE SINGULARITY IS NEAR: WHEN HUMANS TRANSCEND BIOLOGY", P.67, THE VIKING PRESS, 2004. DATAPOINTS BETWEEN 2000 AND 2012 REPRESENT BCA ESTIMATES.





NumberNumberof friendsof routes

2

2





Number<br/>of friendsNumber<br/>of routes2<br/>32<br/>3\*2=6

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Number<br/>of friendsNumber<br/>of routes2233\*2=644\*3\*2=24





 
 Number of friends
 Number of routes

 2
 2

 3
 3\*2=6

 4
 4\*3\*2=24

 5
 5\*4\*3\*2=120





Number<br/>of friendsNumber<br/>of routes2233\*2=644\*3\*2=2455\*4\*3\*2=12066\*5\*4\*3\*2=720











### Finding a shortest tour: how difficult can it be?

Number	Number
of friends	of routes
2	2
3	3*2=6
4	4*3*2=24
5	5*4*3*2=120
6	6*5*4*3*2=720
20	~2.4*10 <sup>18</sup>



Laptop evaluates 1 billion possible routes/second... ... so it needs 675,806 hours to check all routes!







#### Max $z = \sum_{j=1}^{n} c_j x_j$ Constraint $\sum_{j=1}^{n} a_{ij} x_j \le b_i$ $x_j \ge 0$





## Optimization Machine Learning











#### What is the best diet?

Healthy & Sustainable







- Healthy
- Sustainable
- Affordable





...

minimise: such that: costs, environmental impact
energy intake ≥ energy requirement
protein intake ≥ minimum protein intake
vitamin intake ≥ minimum protein intake





minimise: such that: c(d), env(d) $e(d) \ge e_{req}$  $p(d) \ge p_{min}$  $v(d) \ge v_{min}$ 

• • •





#### Multiple objectives

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#### Multiple objectives



















## Optimization Machine Learning













#### Machine learning







#### Machine learning



$$\hat{y} = \beta_0 + \beta_1 x$$







ACGAGACCCTAGAATGCGCCGATAAACAGGCGCTCTAG

TCGAGACCCTAGAACGCGCCGATAGATAGGCGCTCTAG

T C G A G A C A C T A G A A T G C G C T G A T A A A T A G G C G C T C T A G

ACGAGGCACTGGAATGCGCCGATAGACAGGCGCTCTAA

AAGAGACCCTAGAATGCGCCGATAAATAGCCGCTCTAA

AAGAGACACTAGAACGCGCTGATAAATAGCCGCTCTAG

TCGAGGCCCTGGAACGCGCCGATAGATAGGCGCTCTAA







223333334444444 555555566666777 777888888999991010 ................. 10 10 10 11 11 11 11 11 12 12 12 12 12 12 13 13 13 13 14 14 14 14 15 15 15 15 15 16 16 16 16 17 17 -----18 18 18 18 19 19 19 20 20 20 21 21 22 22 ....... TTITIT





## Choosing your machine learning model

- How large is your data?
- Is your prediction a class or a continuous value?
- How complex do you expect the underlying relationship to be?
- Is preprocessing needed?











## Optimization Machine Learning









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#### Long history with WFP

Partnership between TNT and WFP sealed in a Letter of Intent



T(N(T))



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2 Sep.2002



Winning the Franz Edelman Award. TNT moved to a fact-based decision-making system. The Global Optimization (GO) Program, which uses mathematical modeling. Massive savings in CO2 and costs were realized. WFP was very interested.



Optimus wins award for best Humanitarian Innovation. DCHI and Partos awarded Hein Fleuren and Koen Peters for their ground breaking Data Science solutions that enables WfP to feed millions more.





2019 - Zero Hunger Lab is founded by Hein Fleuren and Perry Heijne. The Dutch Ministry of Foreign Affairs and Tilburg University co-fund the innovative research program to enable Zero Hunger by 2030. WfP, Solidaridad, Welthungerhilfe Oxfam, Dutch Food Banks, One Acre Fund and others start co-creation of data science solutions for ZERO HUNGER.....

### ZHL – Bytes for Bites our Theory of Change

**Emergency Relief** 











#### **Better decisions**

Based on Data Science to help our partners (working on SDG2) to help better

→ Impact

 $\rightarrow$  Publications











#### What is possible with ZHL? We focus on Foresight...

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#### ZHL example 1 – OPTIMUS – World Food Programme



## ZHL example 2 – Child Growth Monitor - Welthungerhilfe

# Child Growth Monitor is a mobile app using a smartphone and AI to diagnose malnutrition from image data







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#### **Better height measurements**

- Remove need for heavy, expensive wooden measuring board
- Avoid stretching the child lower stress for child, mother & health worker

#### Better weight measurements

- · Remove need for heavy, expensive scales
- Avoid regular calibration of equipment to maintain accuracy

#### **Digitized data**

- Replace error prone process of plotting points on a paper graph
- Digital data generated instantly difficult to manipulate





# ZHL example 3 – Optimal Humanitarian Response Depot Locations - UNHRD

#### Possible hub locations



#### Using robust optimization



**Goal:** Try to find the optimal number of UNHRD depots and their location

Restrictions: You cannot place a response depot everywhere and we want to be robust: we used several disaster databases





#### Example 4 - ENHANCE: Environment, Nutrition and Health Analytics for National, Consumer and Emergency diets



#### Example 5 - Infrastructure after a disaster



#### Question:

Which nodes and links in the infrastructure to repair first after a natural disaster?

#### Development

An algorithm to quickly determine most important links and nodes

(b) Top 10% importance

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#### Zero Hunger Lab Solution:

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[+] The solution can be deployed with only limited info: a link-node representation is needed. (Easy through OpenStreetMap).

[++] The method is shown to be fast and provides interpretable information on the network (see picture of Puerto Rico)

[-] A cloud-based dashboard and deployment has to be developed for the solution to be distributed.





(b) Top 10% importance.

Figure 34: Importance figures for the Puerto Rico test case.

### Example 6 - Coping strategies of urban refugees



- Interdisciplinary research with prof. Conny Rijken from the Law Faculty
- Work together with CARE NL and CARE Greece
- 6 students from Tilburg University conducted questionnaires among 300 urban refugees
- Athens & Thessaloniki; Syrians, Afghans and misc. group
- Goal: identify coping strategies, vulnerability to labour and sexual explatation
- Approximately 100 questions
- Not 'big data' but gold mine in terms of relations between data elements





#### Example 6 - Some results on living conditions



Figure 7: To Whom They Turn for Help

Insightful basic analysis



Figure 22: Correlation Matrix of Accommodation and Living Conditions



## Attention points in practice!



## WFP: How are we going from pilot to scale?

- NOBODY believes in Math....
- A small game helped
- Master thesis students
- First version used and PhD



• Now attention of senior management and worldwide roll-out



#### What does a data scientist do together with the organization?



#### Possibilities in Predictive & Prescriptive with ZHL



Venn diagram of methods (or combinations) used in the literature



Picture from: Katerina Lepeniotia, Alexandros Bousdekisa, Dimitris Apostolouab, Gregoris Mentzas, Int Journal of Information Management 2020

#### Our start-up sponsors

#### Ministry of Foreign Affairs The Netherlands

- ZHL perfectly fits in their policy 'Invest in Perspective'
- Support for 3 years



# Tilburg School of Economics & Management, The Netherlands

- ZHL works closely with Operations Research, Econometrics & Machine learning researchers
- Support for 5 years

**#5** worldwide in Business Administration Shanghai ARWU 2019



tudents
f which 26% international

400 academic staff of which 50% international

Idea is that with the initial funding we can start projects with our partners and then look jointly for funding



Thank you for your attention! And please reach out if you think ZHL can help you!!

