

**Guido Camps PhD DVM**  
VoedingNL22 | Biologisch ritme en voeding | 17 juni 2022

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## Biologisch ritme en techniek

Wat ga ik vertellen

- Tracken van
  - Stress
  - Slaap
  - Voeding

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## Biologisch ritme en techniek

Tracken van stress

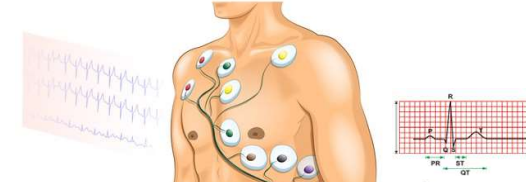
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## Meten van hartslag


ECG is de gouden standaard




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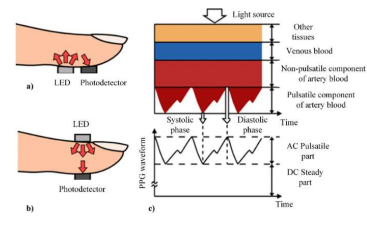


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## Photoplethysmography (PPG)



Ref 1

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These results suggest changes in the morphology of PPG pulses possibly revealing marks of arterial stiffness occurring due to psychological stress.

Two line graphs showing PPG pulse morphology. The top graph is labeled 'Normal State of Subject 2' and shows regular, consistent pulses. The bottom graph is labeled 'Stress State of Subject 2' and shows pulses that are noticeably narrower and taller, indicating changes in arterial stiffness. Both graphs plot Amplitude (µV) on the y-axis (0 to 1000) against Time (ms) on the x-axis (0 to 2000).

Ref 2, 3

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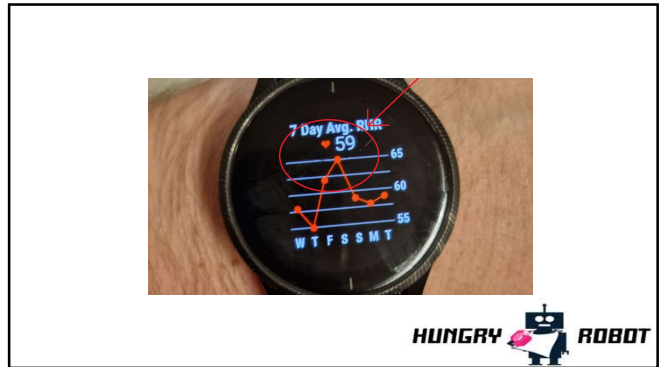
### Biologisch ritme en techniek

Tracken van stress - conclusie

Therefore, the outcome of this study suggest the reliability of implementing PPG signal for stress recognition.

Gegeven de aanname dat hartslag gezien wordt als marker van stress, dan zijn deze metingen zijn dus betrouwbaar genoeg om een indicatie te geven van stress.

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### Kleine inkijk in de toekomst

Apple seeks patent on technology that will be used to monitor Apple Watch users' blood sugar readings

*If Apple can make the technology work, those with the Series 7 Apple Watch who are insulin dependent diabetics will be able to monitor their blood sugar without paying for the disposable test strips. More importantly, they won't have to stick their fingers in a needle. Insulin dependent diabetics don't like to go through the process of obtaining a reading, the new feature could lead to improved monitoring on the part of these patients and help them control their diabetes better. And the Apple Watch will eventually pay for itself since there are no more test strips to buy.*

A block diagram showing the system architecture for blood sugar monitoring. It includes a 'SIGNAL PROCESSOR' (101), a 'BASEBAND' (102), a '100' component (104), and an 'OBJECT' (105).

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### Biologisch ritme en techniek

Tracken van slaap

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### Meten van slaap

polysomnography (PSG) is de gouden standaard




Ref 4


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Wrist actigraphy is based on the principle that physical movements are increased during wakefulness and reduced during sleep


Less movement

0-7 PLMs an hour




Average

13 PLMs an hour



More movement

16+ PLMs per hour



Ref 5, 6

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### Meten van slaap – wat is er op de markt?

software



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### Meten van slaap – wat is er op de markt?

Smart watch gebaseerd




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### Meten van slaap – wat is er op de markt?

Dedicated tracker




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### Meten van slaap

Validiteit



*It has been found to have a reasonable degree of agreement with PSG, with reported agreement rates of 78.8–89.7% for sleep and 48.5–79.8% for wake*

*However, its validity in special populations such as the elderly, in subjects with poor sleep quality, or in those with major health problems is not well-established*

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## Biologisch ritme en techniek

Tracken van slaap - conclusie

Slaap kan gemeten worden, maar algoritmes geven geen zekerheid over hun resultaat.

Vooraf bij de voor ons interessante subgroepen is er twijfel over de validiteit, maar het geeft wel een indicatie.



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## Biologisch ritme en techniek


Tracken van voeding



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Kijkje in ons huidig onderzoek

Wanneer eten we?  
Hoe eten we?  
Wat eten we?



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### Wanneer eten we?



Femke de Gooijer



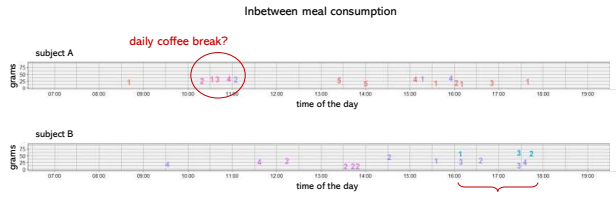
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### When do people eat?

Inbetween meal consumption

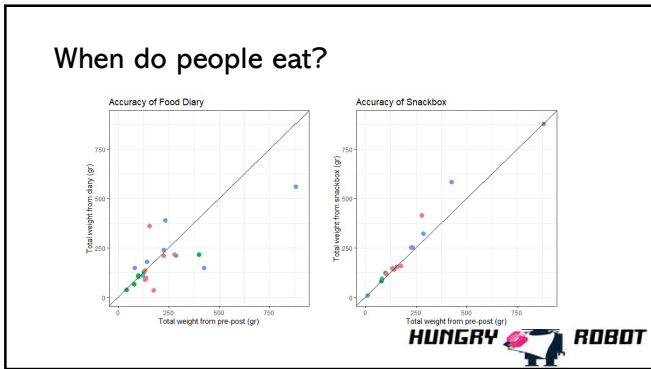


subject A

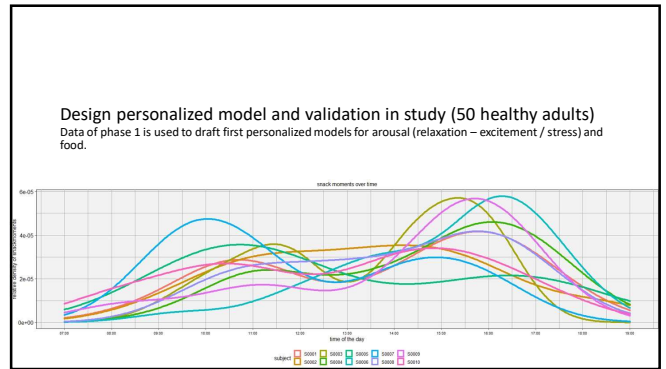
subject B



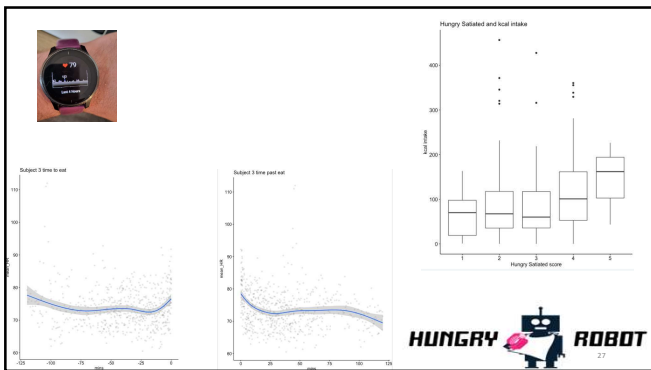
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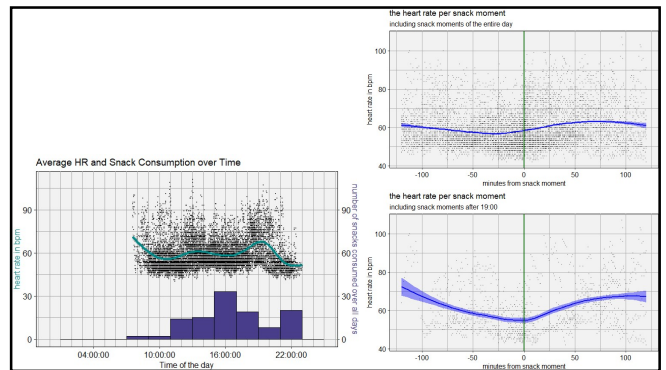
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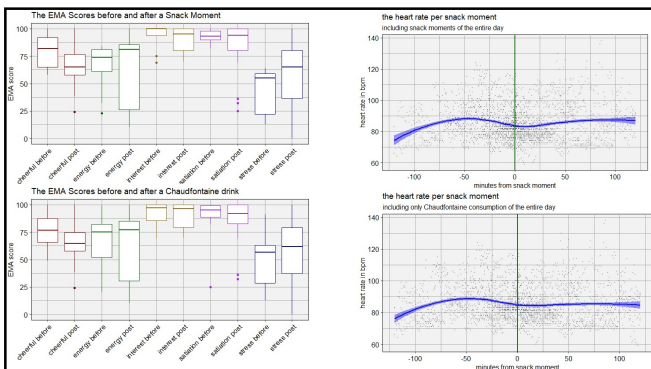
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### Wanneer eten we?

**Eten Drinken Radar!**

Chunzhuo Wang

Prof. Bart Vanrumste Prof. Hans Hallez

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### Eten

- Sensor: Shimmer3 IMU wristband
- Collected Dataset:
  - 24 meal sessions from 24 subjects
  - 1461 bites in total
- Model:
  - 1D-TCN
  - Conv1d
  - Dilated layer
  - Residual connection
- Results: F1-score 94.4%

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### Model: Multi-Stage Temporal Convolutional Network (MS-TCN)

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### Result : Leave-one-subject-out (LOSO) Method

Results:  
F1-score : ~95.0 %

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### Drinking

#### Challenges

- Distribute in all over the day
- Sparse
- Non-specific hand

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### Data collection

#### Dataset description:

- Dataset I (short term)- (DX-I)
  - 13 participants,
  - 486 drinking events: 101(L):266(R):43(L&R)
  - 10.3 hour
    - Duration ratio left hand null : drinking = 32.7 : 1
    - Duration ratio right hand null : drinking = 21.6 : 1
- Dataset II (long term)- (DX-II)
  - 7 participants ( from 10am to 4 or 5 pm)
  - 314 drinking events: 142 (L) :152 (R) : 10(L&R)
  - 45.2 hour
    - Duration ratio left hand null : drinking = 218.7 : 1
    - Duration ratio right hand null : drinking = 175.1 : 1

Results:  
F1-score : 90.0 %

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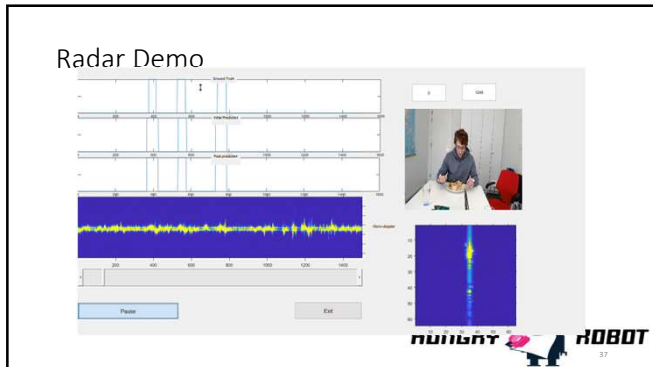
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### 3. Radar-based Eating Gesture Detection

- Sensor: TI FMCW radar
- Collected Dataset:
  - 22 meal sessions from 22 subjects
  - 1138 bites in total
- Input data:
  - Range-Doppler Cube
  - 25 Frames per Second
  - 64 x 64 per frame
- Model:
  - 3D-TCN
  - Conv3d
  - Dilated layer
  - Residual connection
- Results: F1-score 93.3%

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### Hoe eten we?

Automatische registratie van:

- Houding
- Happen
- Slikbewegingen
- Kauwbewegingen

Michele Tufano

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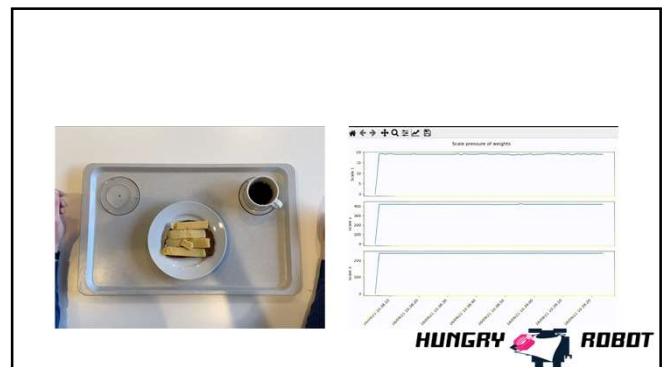
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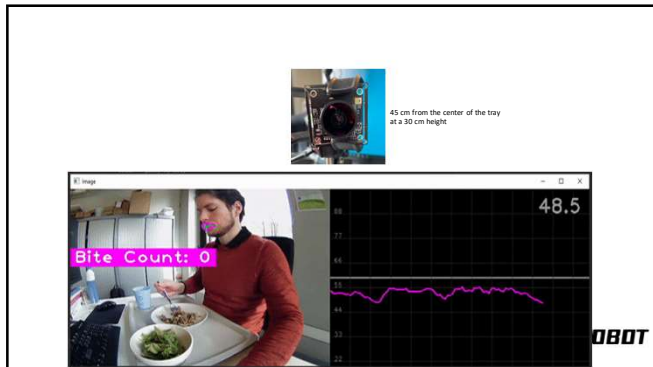
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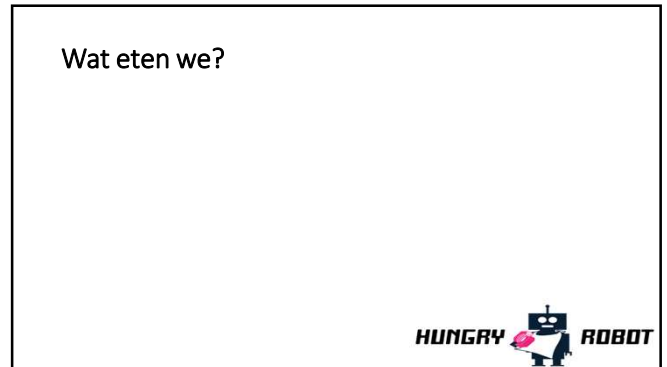
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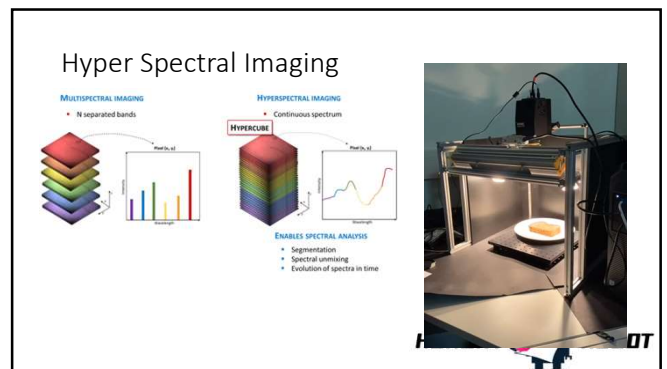
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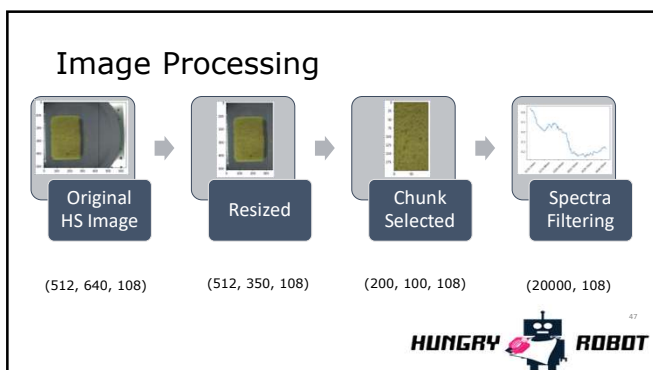
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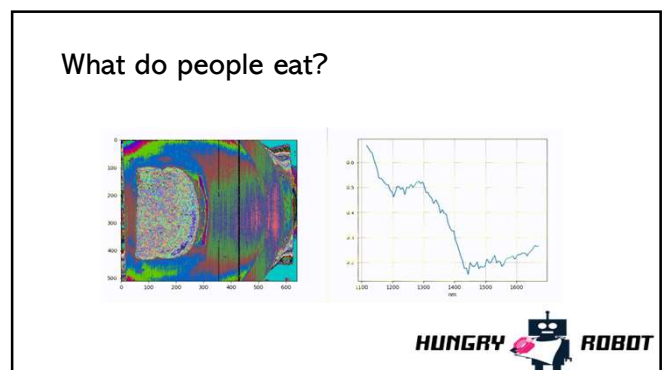
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- **Model parameters;** 3 hidden layers, adam solver, relu activation, 1000 epochs
- **Evaluation metrics problem;**
  - multi label multi output classification, e.g. no confusion matrix or other straightforward metrics
- Custom **accuracy score** calculated;
  - 0.8146
- **Conclusion;**
  - Higher granularity needed
  - → macronutrients

Success areas	Problem areas
<ul style="list-style-type: none"> <li>• Water vs. whole wheat</li> <li>• Fatty vs. carbs</li> <li>• Cheese vs. jelly</li> <li>• Butter vs. jelly</li> </ul>	<ul style="list-style-type: none"> <li>• Fatty overlap; Butter &amp; low fat cheese vs. full fat cheese vs peanut butter</li> <li>• Carby overlap; Sugary spread vs. bread carbs</li> </ul>

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## Als dit allemaal werkt, dan weten we:

Wat je eet, wanneer je eet en hoe je eet, en dat geheel automatisch.

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## Biologisch ritme en techniek

Tracken van voeding - conclusie

Er komen mooie methoden aan, maar de grote vraag is of deze overeind blijven in de echte wereld. Voor de komende jaren blijven de 'ouderwetse' methoden de belangrijkste bron van informatie.

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## Biologisch ritme en techniek

Uiteindelijke conclusie

Qua hartslag, stress en slap is een (relatief goedkope) tracker wellicht een slimme investering.

Qua voeding zijn we nog niet zo ver.

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## Referenties

1. Dzedzicki, Andrius & Kalkauskas, Arturas & Bučinskis, Vytautas. (2020). Human Emotion Recognition: Review of Sensors and Methods. *Sensors*. 20. 592. 10.3390/20030592.
2. S. Banerjee, R. Balak, J. Lazaro, V. Manotas, P. Jaguna and E. Gil. "A two step Gaussian modelling to assess PPG morphological variability induced by psychological stress." *2021 Computing in Cardiology (CinC)*, 2021, pp. 1-4, doi: 10.22488/CinC.2021.270-035.
3. Halimi, Noor & Sidek, Khairul & Mansoor, H. (2017). Stress Recognition Using Photoplethysmogram Signal. *Indonesian Journal of Electrical Engineering and Computer Science*. 8. 495-501. 10.11591/ijeecs.v8.i2.pp495-501.
4. Bhanu Prakash Kolla, Subir Mansulkhani & Meghna P. Mansulkhani (2016). Consumer sleep tracking devices: a review of mechanisms, validity and utility, *Expert Review of Medical Devices*, 13:5, 497-506, doi: 10.1586/17444420.16.1373-708
5. Tilmann, J., Urbain, I., Kotheure, M.J., et al. Algorithms for sleep-wake identification using actigraphy: a comparative study and new results. *J Sleep Res.* 2009;18(1):85-98.
6. Sadeh A. The role and validity of actigraphy in sleep medicine: an update. *Sleep Med Rev.* 2011;15(4):259-267.

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