



Data Ecosystems
for Food Animal Agriculture



Title: Open-sourcing Behavioral Algorithms for Ruminant Welfare Monitoring using Raw Wearable Sensor Data

Abstract number: 41327.

Session: 67 - PLF for health and welfare - Part 2.

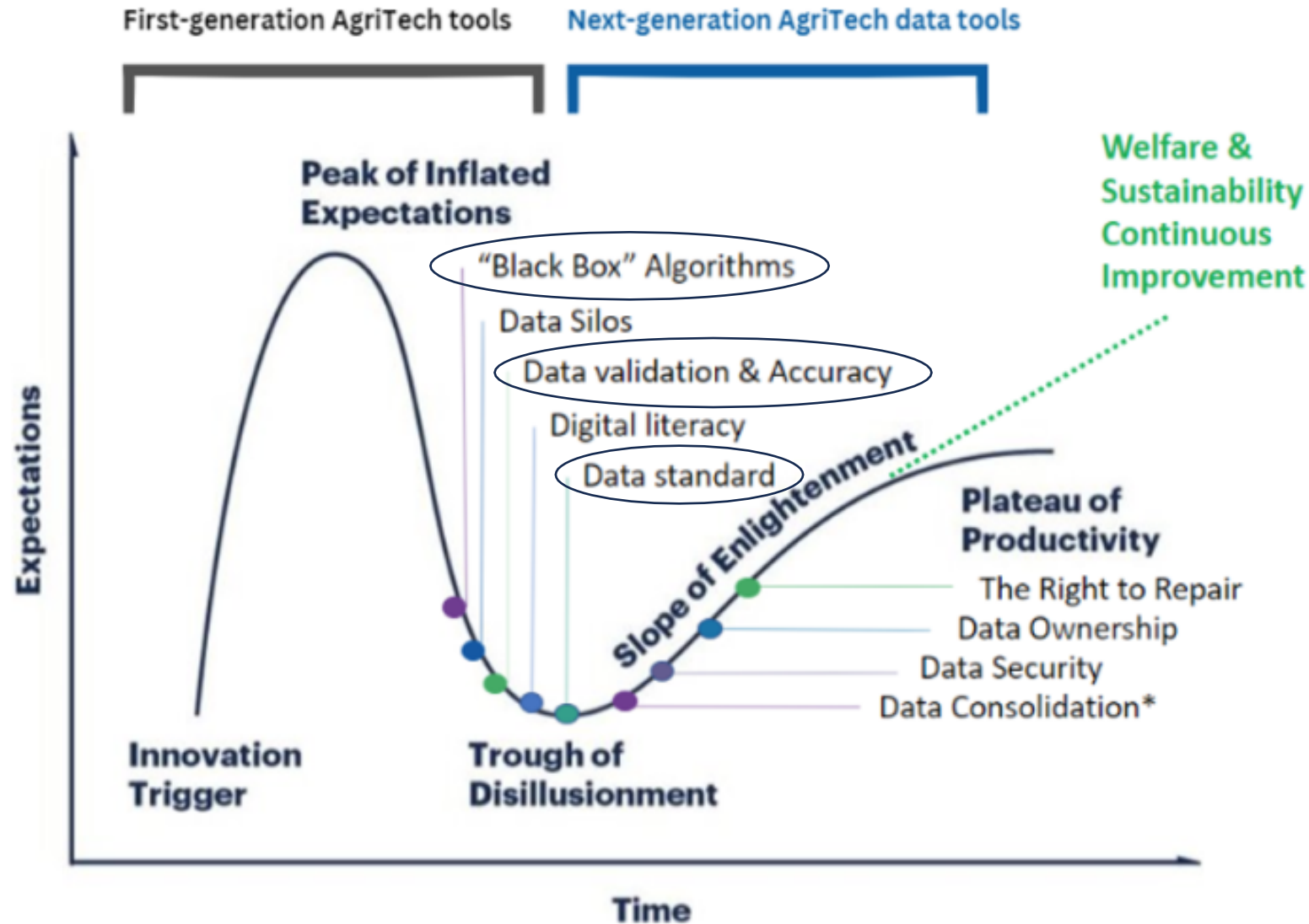
August 30th, 2023.

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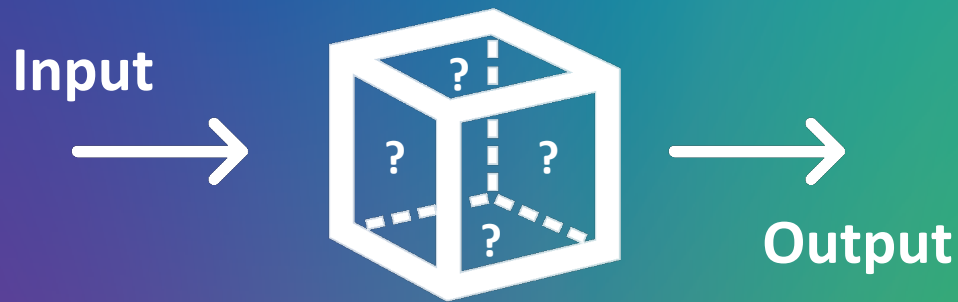
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The Hype Cycle In Food Animal Agriculture



What are Blackbox Behavioral Algorithms (BBA)



Diakopoulos, 2014

Using Machine Learning and Behavioral Patterns Observed by Automated Feeders and Accelerometers for the Early Indication of Clinical Bovine Respiratory Disease Status in Pre-weaned Dairy Calves – Cantor, 2022

Sensitivity and specificity issues

Use of a Tri-Axial Accelerometer Can Reliably Detect Play Behavior in Newborn Calves – Gladden, 2020

Motion index a BBA – “Crude method of behavioral analysis”

IceTag™ Devices: Feasibility for Measuring Activity and Postures in Gilts - Pearsons, 2015

Same algorithm – different species

Stygar et al 2021 - 18 commercially available sensors, 30% validated, all BBA.

Today ~48 different commercial sensor suppliers. Unknown validation rate

Current Wearable Data & BBA

15-minute summary file, 3-axis accelerometers

Column Labeling

BBA

Start	End	MI	Steps	Standing	Lying time	Standing changes
2017-08-31 00:00:00+00:00	2017-08-31 00:15:00+00:00	0	0	00:00.00	00:15:00	0
2017-08-31 00:15:00+00:00	2017-08-31 00:30:00+00:00	19	3	00:08.38	00:06:22	2
2017-08-31 00:30:00+00:00	2017-08-31 00:45:00+00:00	0	0	00:00.00	15:00:00	0
2017-08-31 00:45:00+00:00	2017-08-31 01:00:00+00:00	0	0	00:00.00	15:00:00	0
2017-08-31 01:00:00+00:00	2017-08-31 01:15:00+00:00	0	0	00:00.00	15:00:00	0

Second-to-second data file, 3-axis accelerometers

Column Labeling

BBA

Date	Time	Motion Index	Standing [t]	Lying Time [t]	Steps	Lying Bouts
12/07/2016	10:30:41	1	00:00.0	00:01.0	0	0
12/07/2016	10:30:42	0	00:00.0	00:01.0	0	0
12/07/2016	10:30:43	0	00:01.0	00:00.0	0	0
12/07/2016	10:30:44	0	00:01.0	00:00.0	0	0
12/07/2016	10:30:45	0	00:01.0	00:00.0	0	0

Raw Data

Binary



Human readable data outputs/Parsing



Pre-check Analysis, validation, integration, and ML application

```
10011110 11101100 10000110 10010110 00011011 10001011 00101011 11111111
00000001 01000010 00100000 01000000 10110010 11110101 01101011 11011101
00111100 10001010 11010111 10100001 10011101 10101011 10011111 10001001
10001010 10110111 01010011 01000101 10000110 00110011 01001011 00011001
01010010 11011001 01100001 11010110 00101010 11001111 10011100 00111010
11100010 00011001 11101010 10101101 01010000 11001010 10110010 11010001
11111001 10100010 01011000 01011100 01011101 11011000 11001101 10101000
00001001 10111001 10101111 11110000 01100010 10111100 10000000 10100100
00101001 01110100 00010100 10100110 00101010 00000101 01001001 00101101
00110111 10011000 00010100 10111101 00010101 10000110 10111000 01011010
00101111 01001101 11001000 10110110 00111000 10000001 00111010 00111101
00110001 01110011 01111000 10111101 00011011 11110111 10110000 10011101
00010111 01110000 01100110 01100110 01000110 00101100 00110000 01111101
```

Date	Time	Timezone	X_Accel	Y_Accel	Z_Accel	X_Mag	Y_Mag	Z_Mag	X_Gyro	Y_Gyro	Z_Gyro
6/14/2023	3:49:27.60	UTC-04:00	3.919999	-3.69	-8.83	-26.5	31	22.75	-0.15599	-0.31307	0.111265

```
6 2022-11-23,00:50:02,UTC-06:00,-0.1531406464,-0.1531406464,-9.8010013696,-0.15638150097869194,0.07819075048934597,0.9773843811168246,0.07168,-0.03584,-0.03584
7 2022-11-23,00:50:02,UTC-06:00,-0.1531406464,-0.1531406464,-9.954142016,-0.15638150097869194,0.07819075048934597,0.9773843811168246,0.07168,-0.03584,-0.03584
8 2022-11-23,00:50:02,UTC-06:00,-0.1531406464,-0.1531406464,-9.954142016,-0.15638150097869194,0.07819075048934597,0.9773843811168246,0.03584,-0.03584,-0.03584
9 2022-11-23,00:50:02,UTC-06:00,-0.1531406464,-0.1531406464,-9.8010013696,-0.15638150097869194,0.07819075048934597,0.9382890058721516,0.03584,-0.03584,-0.03584
10 2022-11-23,00:50:02,UTC-06:00,-0.1531406464,-0.1531406464,-9.8010013696,-0.15638150097869194,0.07819075048934597,0.9773843811168246,0.03584,-0.03584,-0.03584
11 2022-11-23,00:50:02,UTC-06:00,-0.1531406464,-0.1531406464,-9.954142016,-0.15638150097869194,0.07819075048934597,0.9382890058721516,0.07168,-0.03584,-0.03584
12 2022-11-23,00:50:02,UTC-06:00,-0.1531406464,-0.1531406464,-9.954142016,-0.15638150097869194,0.07819075048934597,0.9773843811168246,0.07168,-0.03584,-0.03584
13 2022-11-23,00:50:02,UTC-06:00,-0.1531406464,-0.1531406464,-9.8010013696,-0.15638150097869194,0.07819075048934597,0.9773843811168246,0.07168,-0.03584,-0.03584
14 2022-11-23,00:50:02,UTC-06:00,-0.1531406464,-0.1531406464,-9.954142016,-0.15638150097869194,0.07819075048934597,0.9773843811168246,0.03584,-0.03584,-0.03584
15 2022-11-23,00:50:02,UTC-06:00,-0.1531406464,-0.1531406464,-9.954142016,-0.15638150097869194,0.07819075048934597,0.9382890058721516,0.03584,-0.03584,-0.03584
16 2022-11-23,00:50:03,UTC-06:00,-0.1531406464,-0.1531406464,-9.954142016,-0.15638150097869194,0.07819075048934597,0.9382890058721516,0.07168,-0.03584,-0.03584
17 2022-11-23,00:50:03,UTC-06:00,-0.1531406464,-0.1531406464,-9.8010013696,-0.15638150097869194,0.07819075048934597,0.9382890058721516,0.07168,-0.03584,-0.03584
```

Wearable Data Standards

- 3 Axis, 6 Axis, 9 Axis
 - IMU/IMMU type
- Pre-check programs
- Labeling convention
 - Date time format
 - ID Format
- Sampling Rate (Hz)
- Sensor bias
- Error rates
- Edit rates
- Latency
- Other Metadata

- **Define Standard**

- Academic community, in concert with commercial enterprises, collaborate to define acceptable Raw Data (Siegford, 2023)

- **Sensor Fusion for Raw Data**

- Precheck or parsing program on Accelerometer data (Riabonff 2019, Bloch 2023)
- Parsing Program for Data

- Standard Data enables **Behavioral Algorithmic Development**, deployable in open-source Initiative

- Gouming, 2023 Open-source ML raw data
- Peng, 2023 Raw data behavior validation
- Bloch, 2023 CNN on acceleration

ML Library

Housing, Age, Breed, Region

- Lying time
- Standing
- Step
- Feeding
- Drinking
- Head bobbing
- Tongue rolling
- Licking
- Hop
- Leap forward
- Leap Sideways
- Running
- Ruminating
- Sitting
- Lying side
- Speed/locomotion
- Weaning Ruminantion
- Etc...



Public **GitHub** to collaborate and share code.

1. Documentation (Readme.)
2. User support through a communication channel
3. Choose a type of license that supports the level of use
4. Protect project code by implementing security features
5. Terms & Conditions for the right of contribution
6. Outline the best language when writing GitHub content
7. Peer review, releasing early and often, and continuing testing and integration of code.
8. Accurate licensing information is crucial
9. git, the version control of GitHub
10. Ability to certify that their contribution to the project is their own.
11. Agreement between the developer and the project owner or maintainer.



Industry and academic engagement in libraries is critical
(Siegford 2023)



Benefits & Value

- Unlocking **Raw Data** for use in welfare, behavioral, and health Algorithms
 - Breed, Age, region, housing, farming system(s), etc.
- **Pre-check Raw Data** outputs, independent of the supplier
 - Improved decision support
 - Higher-quality data for ML/AI research and applications
- **Data standards**
 - Pathway to Future data from cameras, GPS, or RX and RSSI
 - Higher quality data for deeper welfare, behavioral and health research
 - Coordinating interdisciplinary teams from ethologists to computer scientists
- Establish **ML library**.
 - Faster Improvement and research of welfare and sustainability
 - Interoperability and Agile development and deployment of welfare, behavioral, and health ML algorithms



Data Ecosystems
for Food Animal Agriculture



Thank you

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