1 # Sensing solutions for improving the performance, health and wellbeing of small

2 ruminants

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7 ## SUPPLEMENTARY FILE

8 **Table S1**: Main types and subtypes of sensors used by Internet of Things (IoT) platforms
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Type	Working principle or measurement	Subtypes
Temperature	Measure the strength of the material, which is a function of temperature	- Thermocouples - RTD (Resistor temperature detector) - Thermistor - Ultrasonic - Infrared
Humidity	Amount of vapour of water in an atmosphere (relative humidity)	- Capacitive - Resistive - Thermal
Proximity	Detects the presence of nearby objects without physical contact based on different operating principles	- Inductive - Capacitive - Photoelectric - Ultrasonic
Pressure	Converts pressure into an electric signal but the working principles are diverse	- Absolute - Gauge - Differential
Chemical and water quality	Signal obtained from correlation with concentration of chemical species against a reference. Problem of drift and saturation	- pH CO_2 - Biosensors
Gas and smoke	Detects airborne particles and gases	- Optical (photoelectrical) - Infrared (frequency absorption) - Ionization - Bolometer (low microwave)
Flow/Level	Amount of substance flowing in an open or closed system	- Point level - Continuous level
Image	Converts optical images into electronic signals (digital camera)	- CCD (charge-coupled device) - CMOS (complementary metal-oxide-semiconductor) - Infrared pixel matrix

Motion	Transforms the physical movement (motion) in a given area into an electric signal	• PIR (Passive IR[1]) detects body heat • Ultrasonic (reflection speed of waves) • Microwave (radio waves)
Accelerometer	Transducer able to measure acceleration (change in velocity with respect to time) due to inertial forces by converting the mechanical motion into an electrical output	• Hall-effect (voltage variation caused by changes in magnetic field) • Capacitive (voltage dependent on the distance between 2 planar surfaces) • Piezoelectric
Gyroscope	Angular velocity (speed of rotation around an axis) usually in 3-axis and combined with accelerometers	• Rotary • Vibrating structure • Optical • MEMS (micro-electro-mechanical systems)
Optical	Physical quantity of light converted into an electrical signal readable by a user or an electronic instrument/device (optical sensor)	• Photodetector • Fibre optic • Pyrometer • Proximity • Infrared

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Table S2: Standard spectrum of radiofrequency bands according to the International Telecommunication Union (ITU) and their main applications (Hz = Hertz; kHz = 10^3 Hz; MHz = 10^6 Hz; GHz = 10^9 Hz; THz = 10^{12} Hz)

Frequency (F)	Wavelength	Abbreviation (name)	Applications
3 to 30 Hz	10^5 to 10^4 km	ELF (extremely low)	Submarine radio.
30 to 300 Hz	10^4 to 10^3 km	SLF (super low)	
300 Hz to 3 kHz	10^3 to 10^2 km	ULF (ultra low)	Submarine and mine radios.
3 to 30 kHz	10^2 to 10 km	VLF (very low)	Submarine and marine radios, time signals, navigation, geophysics, heart-rate monitors.
30 to 300 kHz	10 to 1 km	LF (low)	Amateur and AM (longwave broadcasts) radios, time signals, navigation, industrial and animal e-ID[1] tags (HDX[2] and FDX[3]).
300 kHz to 3 MHz	1 km to 100 m	MF (medium)	Amateur and AM (medium-wave broadcasts) radios, aviation navigation, avalanche beacons.
3 to 30 MHz	100 to 10 m	HF (high)	Amateur, citizens and short-wave broadcasts, over-the-horizon aviation radio and radar, marine and mobile radiotelephony, industrial e-ID tags.
30 to 300 MHz	10 to 1 m	VHF (very high)	Amateur and weather radios, FM and TV broadcasts, ground-aircraft and aircraft-aircraft radios.
300 MHz to 3 GHz	1 m to 10 cm	UHF (ultra high)	TV broadcasts, microwave oven and communications, WLAN[4], 4G mobile, Bluetooth, Wi-Fi, GPR[5], GPS[6], remote control radio, UHF tags.
3 GHz to 30 GHz	10 to 1 cm	SHF (super high)	Satellite radio, radio astronomy, cable and satellite TV broadcasts, modern radar, Wi-Fi, 5G mobile, WLAN, remote sensing.
30 GHz to 300 GHz	1 cm to 1 mm	EHF (extremely high)	Imaging and detection, astronomy, satellite, 5G mobile, WLAN (802.11ad), remote sensing.
0.3 to 3 THz	1 mm to 10^{-6} m	THF (tremendously high)	High resolution microwave imaging (replacing X-rays), spectroscopy, computing, remote sensing.

[1]Electronic identification; [2]Half-duplex; [3]Full-duplex; [4]Wireless local area network; [5]Ground-penetrating radar; [6]Global positioning system.