

LIFELINE: THE LOW COST, IOT VITAL SIGNS MONITOR WITH REAL-TIME ILLNESS PREDICTION

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ABSTRACT

VITAL SIGN MONITORS MEASURE THE BODY'S MOST BASIC FUNCTIONS WHICH ARE CRITICAL SIGNALS NEEDED BY DOCTORS TO MAKE LIFE-SAVING DECISIONS. THESE INCLUDE:

HEART RATE

- INDICATES ARRHYTHMIAS SUCH AS ATRIAL FIBRILLATION (AF), TACHYCARDIA AND BRADYCARDIA

OXYGEN LEVELS (SP02)

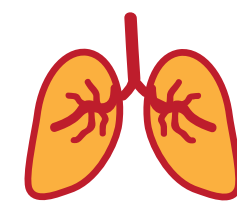
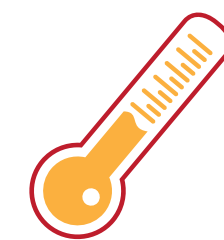
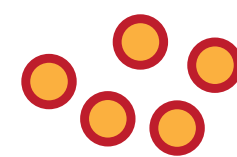
- INDICATES HYPOXIA AND HYPOXEMIA

TEMPERATURE

- INDICATES FEVER, INFECTIONS, INFLAMMATION AND SEPSIS

RESPIRATION RATE

- CAN DROP TO A DANGEROUS LEVEL AFTER SURGERY AND INDICATES SEPSIS, PULMONARY EMBOLISM AND ASTHMA



THE PROBLEM

\$10,000

AVERAGE COST OF A CONVENTIONAL VITAL SIGN MONITOR

CONVENTIONAL MONITORS ARE EXPENSIVE

- HOSPITALS IN DEVELOPING COUNTRIES CANNOT AFFORD ENOUGH CONVENTIONAL VITAL SIGN MONITORS
- AVAILABLE MONITORS ARE ONLY USED FOR THE CRITICALLY ILL PATIENTS, SO ACUTELY ILL PATIENTS ARE NEGLECTED
- THIS LEADS TO LONG WAITING TIMES AND OVERCROWDING OF HOSPITALS

52%

OF PEOPLE IN RURAL AREAS IN DEVELOPING COUNTRIES DON'T HAVE ACCESS TO HOSPITAL CARE [1]

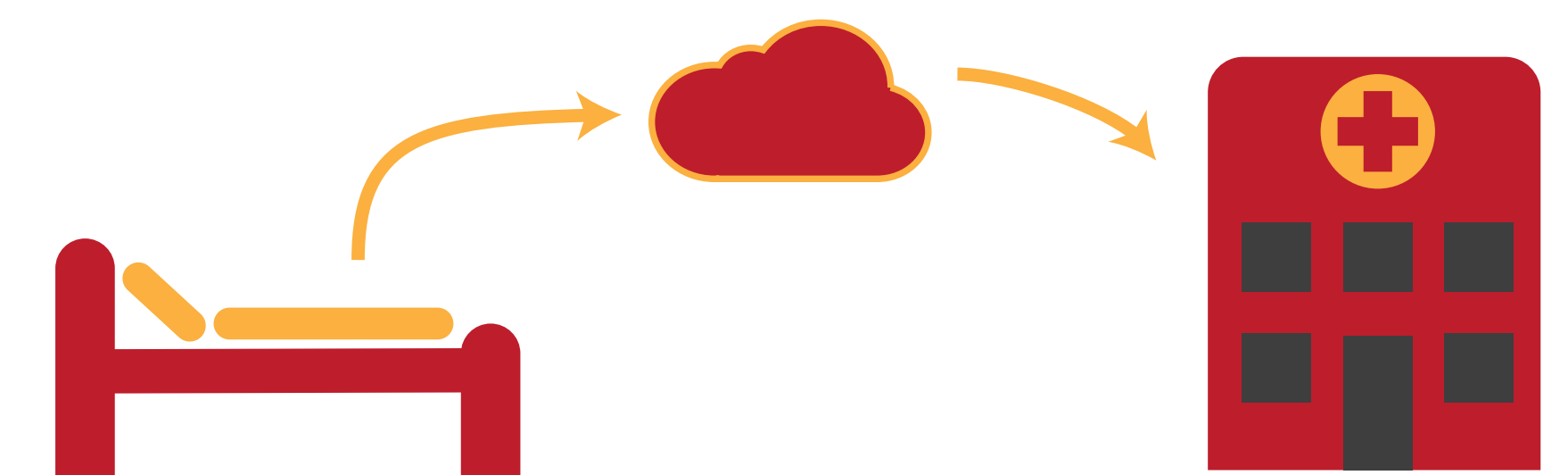
MEDICAL SPECIALISTS ARE LACKING IN RURAL AREAS

- VERY RURAL LOCATIONS LACK MEDICAL SPECIALISTS AS THEY TEND TO WORK IN CITY HOSPITALS, SO MEDICAL CARE IS INACCESSIBLE FOR MANY
- CONVENTIONAL MONITORS DON'T OFFER WIRELESS CONNECTIVITY OR MEANS TO DETECT AN ABNORMALITY, LIMITING THE NUMBER OF PATIENTS A DOCTOR CAN CARE FOR AT ONCE

THE SOLUTION

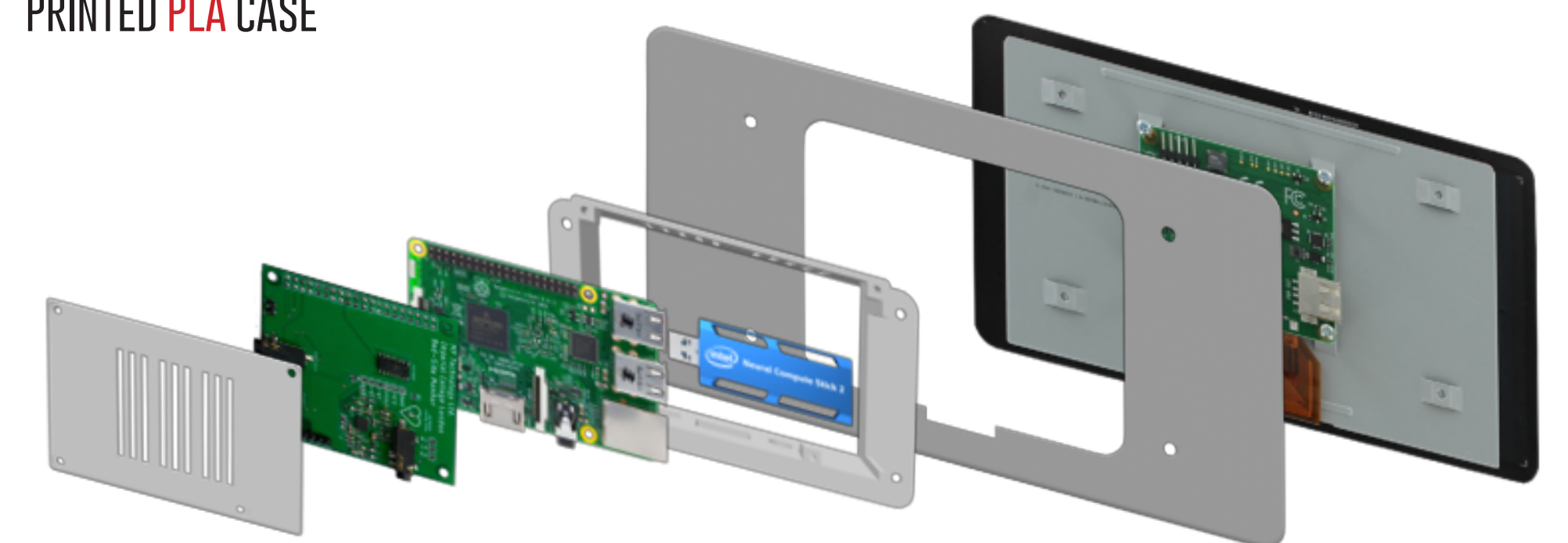
LIFELINE

- LOW-COST IOT DEVICE THAT CAN REMOTELY MEASURE A PATIENT'S VITAL SIGNS FROM ANY LOCATION
- LIVE PATIENT DATA IS STREAMED TO A DOCTOR'S DESKTOP OR PHONE, WHILST BUILT-IN MACHINE LEARNING ALGORITHMS DETECT ANY ABNORMALITIES
- ALLOWS DOCTORS TO CARE FOR SEVERAL PATIENTS IN SEVERAL LOCATIONS AT ONCE, WHILST ALLEVIATING THE OVER-DEMAND FOR HOSPITAL BEDS



- FEATURES A MODULAR DESIGN WHICH ALLOWS UNITS TO BE CUSTOMISED SPECIFIC TO PATIENT NEEDS. THIS MEANS HOSPITALS CAN CUT COSTS BY ONLY HAVING TO BUY AND / OR REPLACE THE PARTS THEY ACTUALLY NEED.
- DEPENDING ON THE CHOSEN CUSTOMISATION OPTION, LIFELINE COSTS BETWEEN £44 -£166.
- LIFELINE IS A DURABLE PRODUCT, HOUSED IN A SECURE AND BIODEGRADABLE 3D PRINTED PLA CASE

£166



HOW DOES IT WORK?

SENSORS

- ECG: ELECTRODES PLACED ON THE SKIN MEASURE THE HEART'S ELECTRICAL ACTIVITY. THE ECG WAVEFORM IS USED TO DERIVE HEART AND RESPIRATION RATES
- PPG: MEASURED USING A REFLECTANCE PULSE OXIMETER ON THE FINGERTIP AND IS USED TO DERIVE BLOOD OXYGEN LEVELS
- TEMPERATURE: MEASURED BY A DIGITAL THERMOMETER
- RAW PPG AND ECG WAVEFORMS ARE DIGITALLY FILTERED IN REAL-TIME

CUSTOM-MADE PCB

- CUSTOM RASPBERRY PI HAT INTERFACES THE SENSORS AND THE RASPBERRY PI
- DEVELOPED TO INTEGRATE WITH ANY TYPE OF RASPBERRY PI

LIFE-SAVING PREDICTIONS

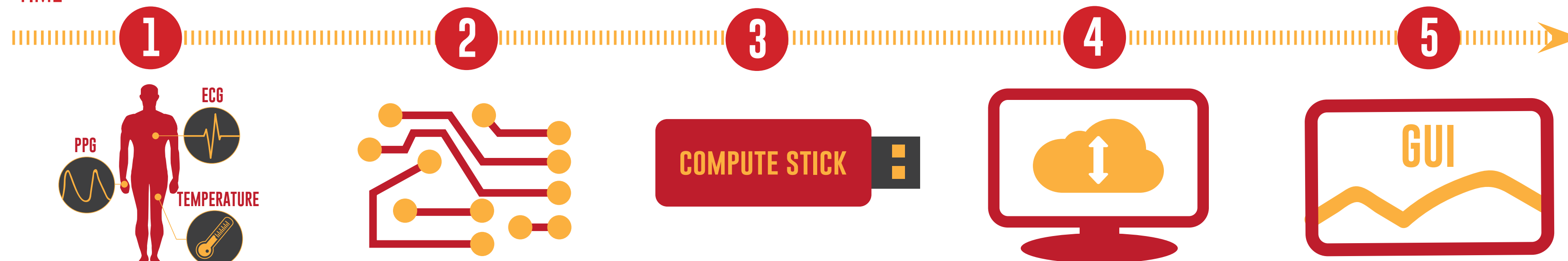
- A DEEP RESIDUAL NEURAL NETWORK DESIGNED AND TRAINED TO DETECT ABNORMALITIES IN ECG SIGNALS
- RUNS ON AN INTEL NEURAL COMPUTE STICK 2, AN OPTIONAL ADD-ON; SIMPLY PLUG IN TO ENABLE REAL-TIME ARRHYTHMIA DETECTION
- NO RELIANCE ON CLOUD COMPUTING OR INTERNET CONNECTION

WEB-APP & DATABASE

- ALLOWS MEDICAL PROFESSIONALS TO MONITOR THEIR PATIENTS REMOTELY ON A DESKTOP OR PHONE
- LOW-LATENCY DATABASE PROVIDES SECURE PATIENT HISTORY STORAGE AND ALLOWS THE PATIENT'S VITAL SIGNS TO BE LIVE STREAMED TO THE DOCTOR
- DOCTORS RECEIVE AN ALERT IF A CRITICAL SITUATION ARISES
- DATABASE ALLOWS HOSPITALS WITH PAPER RECORDS TO DIGITISE PATIENT RECORDS ON-THE-FLY

REAL-TIME BEDSIDE DISPLAY

- 7" TOUCHSCREEN DISPLAY
- INFORMATIVE USER INTERFACE WHICH DISPLAYS REAL-TIME ECG, PPG AND TEMPERATURE WAVEFORMS, IN ADDITION TO HEART-RATE, RESPIRATION RATE AND SP02 VALUES
- OPTIONAL ADD-ON WHICH FACILITATES LINKING A LIFELINE DEVICE TO A PATIENT'S ONLINE RECORD FOR A QUICK AND EFFORTLESS SET-UP



FUTURE WORK

IN THE FUTURE, LIFELINE WOULD BE IMPROVED AS FOLLOWS:

- INTEGRATE NON-INVASIVE BLOOD PRESSURE MONITORING
- INTRODUCE ONLINE LEARNING TO IMPROVE THE ABNORMALITY DETECTION ALGORITHM
- RESEARCH OPTIMAL DIGITAL FILTER METHODS FOR ECG AND PPG REAL-TIME PROCESSING
- INCREASE THE ACCURACY AND PRECISION OF THE DIGITAL VITAL SIGNS BY INTRODUCING MORE ADVANCED SIGNAL PROCESSING TECHNIQUES

[1] WORLD BANK AND WORLD HEALTH ORGANIZATION. "WHO." 13 DECEMBER 2017. [ONLINE]. AVAILABLE: [HTTPS://WWW.WHO.INT/NEWS-ROOM/DETAIL/13-12-2017-WORLD-BANK-AND-WHO-HALF-THE-WORLD-LACKS-ACCESS-TO-ESSENTIAL-HEALTH-SERVICES-100-MILLION-STILL-PUSHED-INTO-EXTREME-POVERTY-BECAUSE-OF-HEALTH-EXPENSES](https://www.who.int/news-room/detail/13-12-2017-world-bank-and-who-half-the-world-lacks-access-to-essential-health-services-100-million-still-pushed-into-extreme-poverty-because-of-health-expenses).