TeleDoc: A Smart Radar-assisted Telehealth Monitoring System

Sanket Lokhande, Hao Xu, Ph.D., Jihwan Yoon Ph.D, Yeongkwon Son
Department of Electrical and Biomedical Engineering
University of Nevada, Reno, email: {slokhande,haoxu} @unr.edu

Project Objectives

- One of the foremost objectives of NASA has been the development of the ability to remotely monitor health of the crew, spacecraft and environment
- Telemedicine is a key component that addresses the wellbeing of the crew members
- This calls development in basically 3 main categories: 1) Sensing, 2) Processing & 3) Reporting

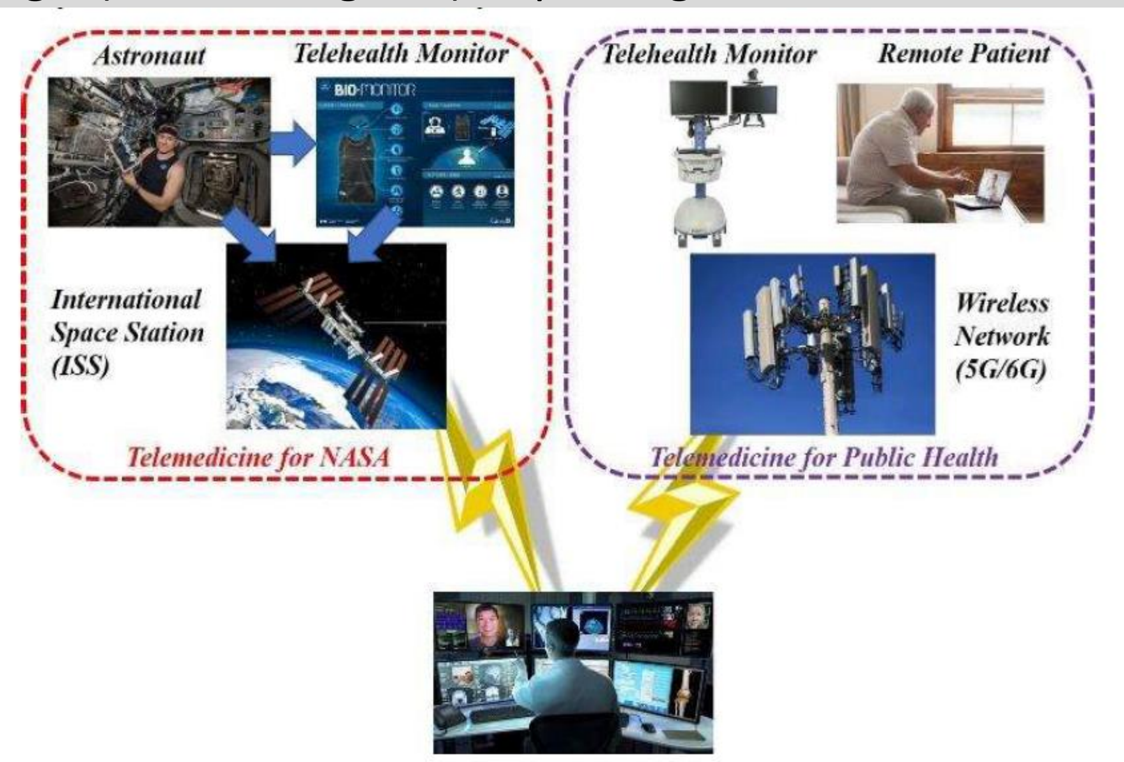

Fig. 1. Telemedicine for NASA and public health.

Project Proposals

- **Goal:** Develop a novel life support system (cardiac and respiration) which is 1) low-cost, 2) portable, 3) contactless & 4) high-quality telehealth monitoring system
- **Challenges**
  - Health monitoring in Space exploration projects will require bulky devices to be carried or they might be invasive restricting movements (***Challenge 1:*** Portability)
  - Dynamic nature of Space exploration will require signal processing techniques that real-time (***Challenge 2:*** Online Deep RL)
  - Ground Control Station will need to analyze any irregularities remotely (***Challenge 3:*** Telehealth Monitoring Platform)
- **Ideas:**
  - Micro-Doppler Radar sensors can detect displacements from 100 µm to a few mm. This is perfectly suited to detect chest displacements caused by cardiopulmonary activity and respiration (***Solution of Challenge 1***)
  - Environmental changes are inherent in the idea of exploration. This can severely hamper the quality of signals. Iterative context aware deep learning techniques are well suited to address the issues (***Solution of Challenge 2***)
  - Continuous monitoring of big data is hard to achieve when portability is in consideration specially in the case of vital sign irregularities. Medical personal intervention in real-time is the highest priority here. We propose a novel telemedicine framework (***Solution of Challenge 3***)

Proposal Overview

- We propose 1) Radar based Vital Sign detection, 2) Deep Learning based Online signal processing and 3) SNN based AI-on-the-chip for event detection

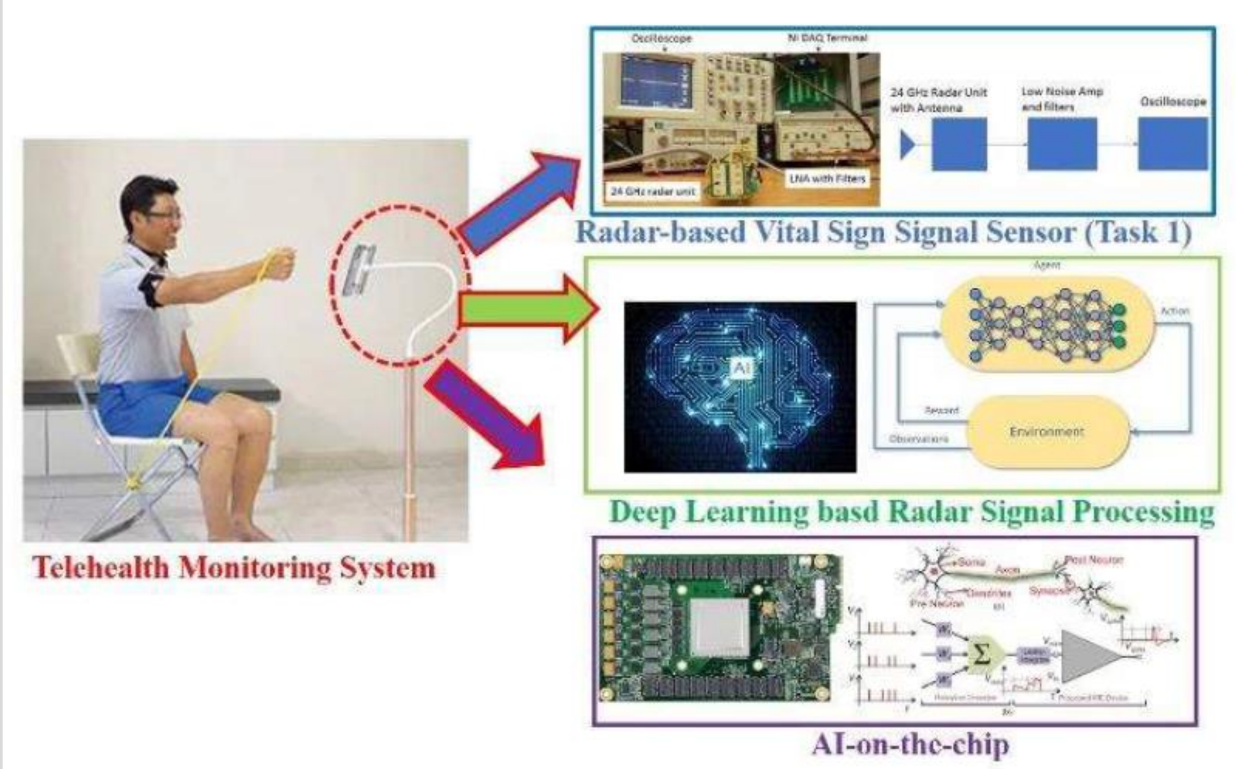

Fig. 2. Proposed smart telehealth monitoring system.

1. Development of Novel Micro-Doppler Radar Physiological Sensor (Micro-DRPS)

- Our Micro-DRPS system is designed to monitor cardiovascular movements of the respiratory system
- With the optimal frequency of 24-24.25 GHz signal, we achieve a reasonable balance between sensitivity and vital sign detection

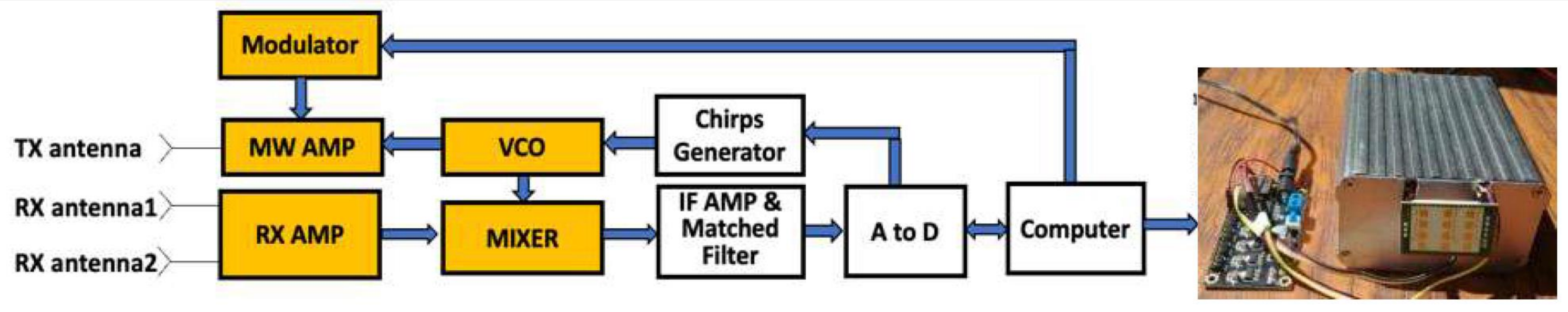

Fig 3. Diagram of a DRPS system capable of tracking target and measuring high-resolution Doppler radar trace of a human heartbeat.

2. Hybrid Deep Reinforcement Learning-Based Online Vital Sign Signal Processing

- With the developed Micro-DRPS system from stage 1, we turn to next challenge of possible motion artifacts with unknown environmental noise
- We develop a Hybrid Deep Reinforcement learning based vital sign detection algorithm that will perform real time monitoring of human health conditions
- The idea here is to seamlessly combine time-based physics-guided reinforcement learning with iteration-based vital signal pattern recognition
- The structure of the proposed RL framework is shown in **Fig. 4** and the experimental results in **Fig. 5**

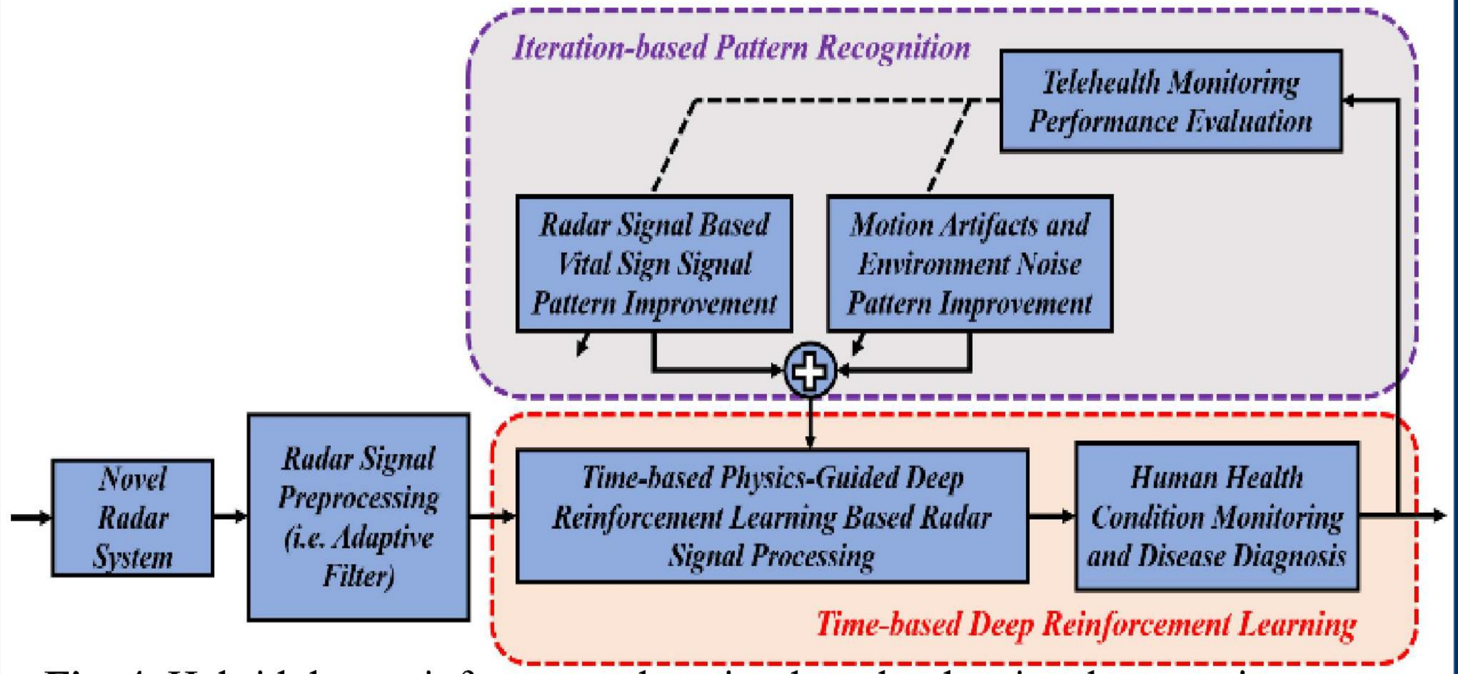

Fig. 4. Hybrid deep reinforcement learning-based radar signal processing architecture.

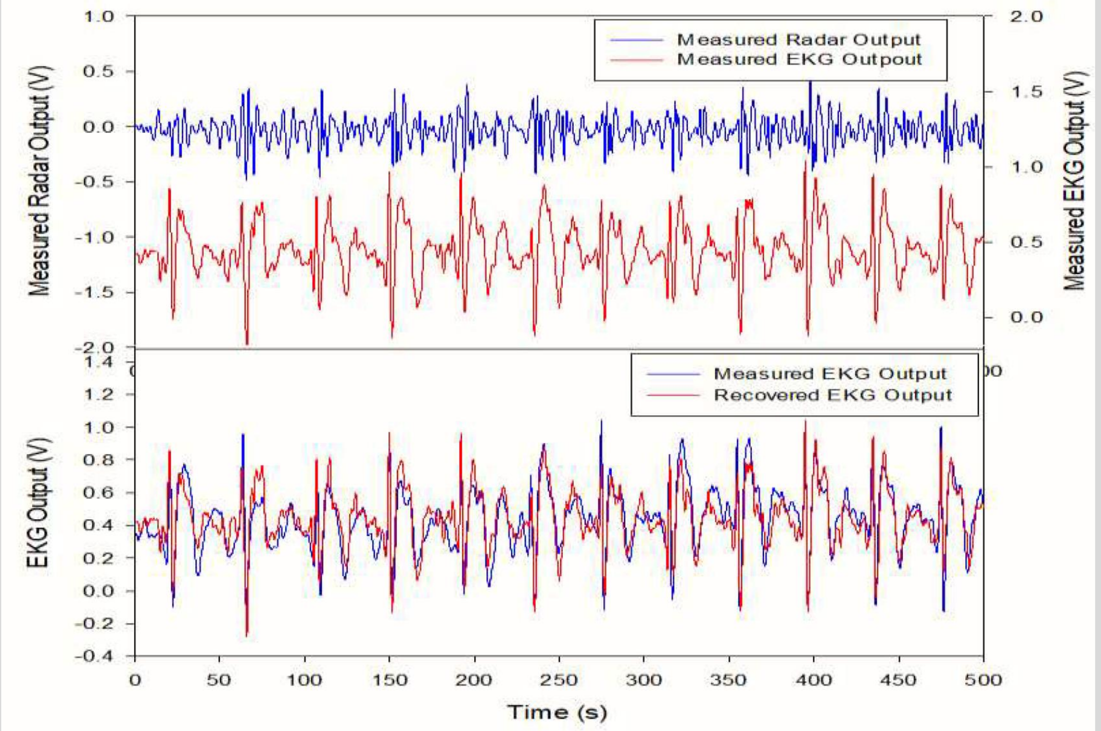

Fig. 5. Human vital signs obtained from sensed data.

3. Smart telehealth monitoring platform with AI-on-the-chip

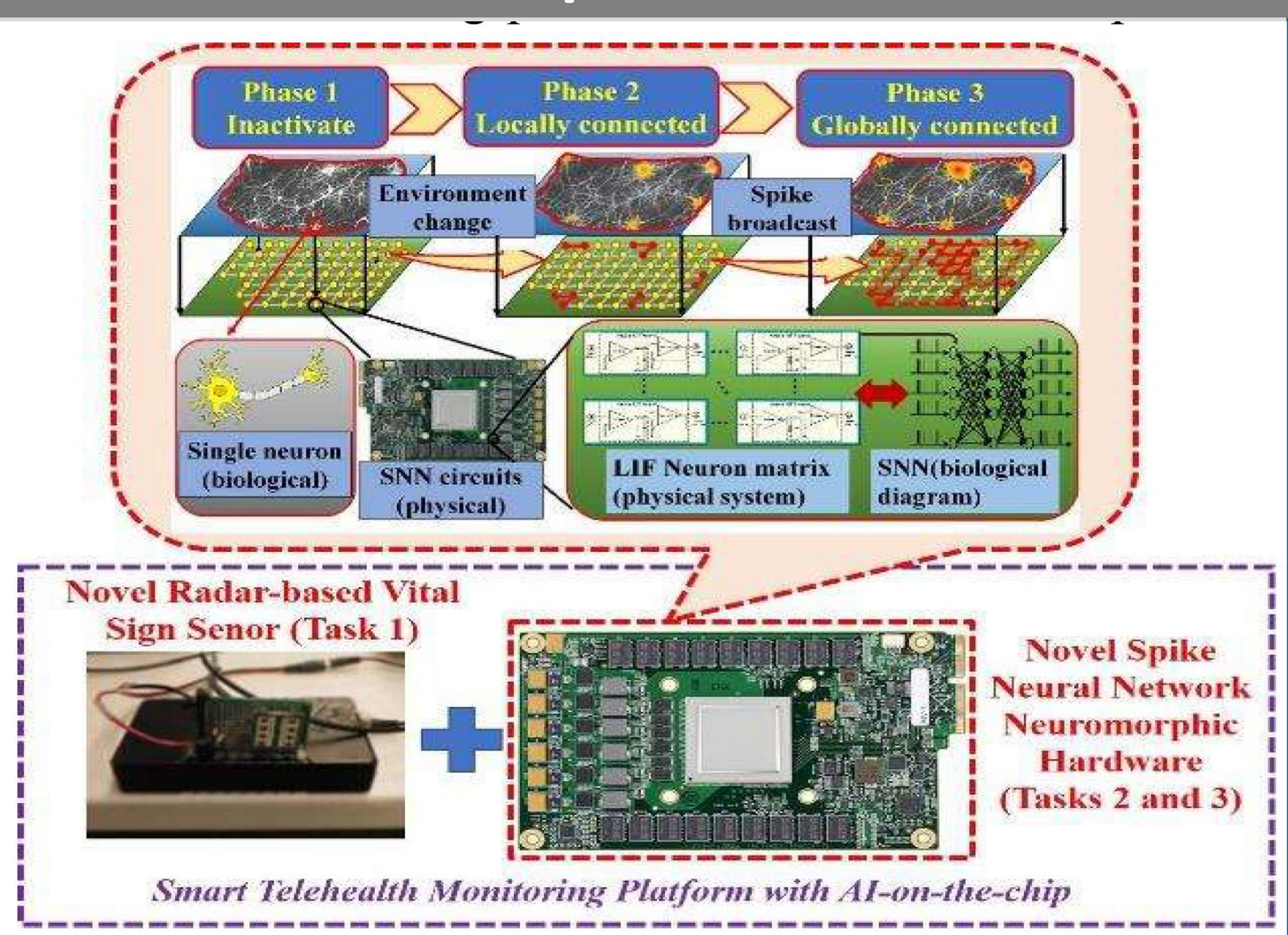

Fig. 6. Smart telehealth monitoring platform at UNR.

- **Fig 6.** shows the proposed implementation of the Telehealth framework