1. Person Existing&Tracking

- **目标：**检测环境中的所有`人体`，标记出每个人体的`坐标位置`；不限人体数量，适应中低空斜拍、人体轻度遮挡、截断等场景 公司： **WAYV AIR**

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> Huang X, Cheena H, Thomas A, et al. `Indoor Detection and Tracking` of People Using mmWave Sensor[J]. Journal of Sensors, 2021, 2021. [pdf]

> Palacios, Joan, et al. "LEAP: `Location estimation and predictive` handover with consumer-grade mmWave devices." *IEEE INFOCOM 2019-IEEE Conference on Computer Communications* . IEEE, 2019. [pdf]

> J. Wang, D. Nolte, K. Tanja, J. Muñoz-Ferreras, R. Gómez-García and C. Li, " `Trade-off on Detection Range and Channel Usage` for `Moving Target Tracking` using FSK Radar," *2020 IEEE Topical Conference on Wireless Sensors and Sensor Networks (WiSNeT)* , 2020, pp. 38-41, doi: 10.1109/WiSNeT46826.2020.9037618. [pdf]

> Zeng, Yunze, et al. "Human tracking and activity monitoring using 60 GHz mmWave." *2016 15th ACM/IEEE International Conference on Information Processing in Sensor Networks (IPSN)* . IEEE, 2016. [pdf]

2. Coarse-grained behavior

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> C. Dinget al., " `Inattentive driving behavior detection` based onportable FMCW radar," IEEE Trans. Microw. Theory Techn., vol. 67,no. 10, pp. 4031–4041, Oct. 2019

.2. Daily Activity

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> Y. Tang, Z. Peng, L. Ran and C. Li, "iPrevent: A novel wearable radio frequency range detector for `fall prevention` ," 2016 IEEE International Symposium on Radio-Frequency Integration Technology (RFIT), 2016, pp. 1-3, doi: 10.1109/RFIT.2016.7578162. [pdf]

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> Wang K, Zhan G, Chen W. `A New Approach for IoT-based Fall Detection System` using Commodity mmWave Sensors[C]//Proceedings of the 2019 7th International Conference on Information Technology: IoT and Smart City. 2019: 197-201.

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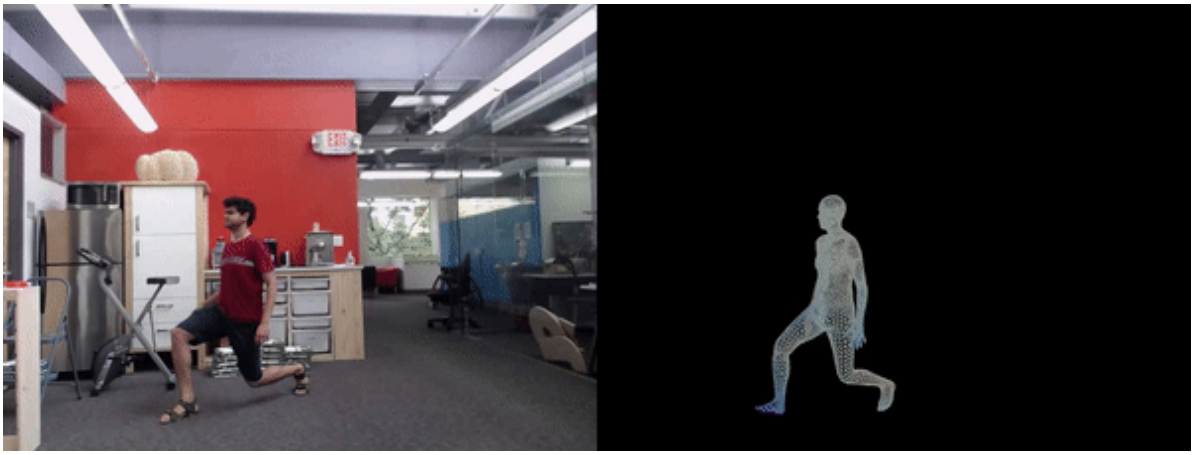

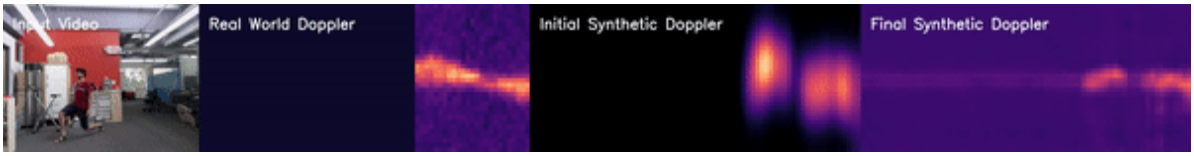

.2. OpenSource RadHAR

> Singh, Akash Deep, et al. "Radhar: Human activity recognition from point clouds generated through a millimeter-wave radar." *Proceedings of the 3rd ACM Workshop on Millimeter-wave Networks and Sensing Systems* . 2019. [pdf] [code]

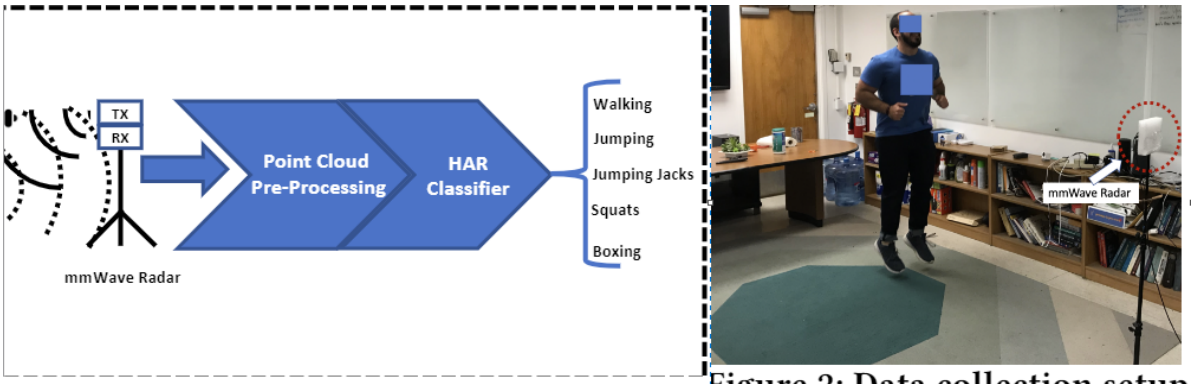

Figure 2: Data collection setup

.3. Sleeping

> H. Hong et al., "Microwave Sensing and Sleep: `Non contact Sleep-Monitoring` Technology With Microwave Biomedical Radar," in IEEE Microwave Magazine, vol. 20, no. 8, pp. 18-29, Aug. 2019, doi: 10.1109/MMM.2019.2915469.

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> . Baboli, A. Singh, B. Soll, O. Boric-Lubecke, and V. M. Lubecke,“Good night: Sleep monitoring using a `physiological radar monitoring` system integrated with a polysomnography system,”IEEE Microw.Mag., vol. 16, no. 6, pp. 34–41, Jul. 2015.

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> H. Hong, L. Zhang, C. Gu, Y. Li, G. Zhou, and X. Zhu, “Noncontact `sleep stage estimation` using a CW Doppler radar,”IEEE J. Emerg. Sel.Topics Circuits Syst., vol. 8, no. 2, pp. 260–270, Jun. 2018.

> F. Linet al., “SleepSense: A noncontact and cost-effective sleep monitoring system,”IEEE Trans. Biomed. Circuits Syst., vol. 11, no. 1,pp. 189–202, Feb. 2017.

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> D. V. Q. Rodrigues and C. Li, "Noncontact Exercise Monitoring in `Multi-Person Scenario With Frequency-Modulated Continuous-Wave Radar,` " 2020 IEEE MTT-S International Microwave Biomedical Conference (IMBioC), 2020, pp. 1-3, doi: 10.1109/IMBIoC47321.2020.9385031. [**pdf**]

3. Fine-grained behavior

.1. hand gesture

> Ren Y, Lu J, Beletchi A, et al. Hand gesture recognition using 802.11 ad mmWave sensor in the mobile device[C]//2021 IEEE Wireless Communications and Networking Conference Workshops (WCNCW). IEEE, 2021: 1-6.

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> . Lienet al., “ `Soli` : Ubiquitous gesture sensing with millimeter waveradar,”ACM Trans. Graph., vol. 35, no. 10, pp. 1–19, 2016

.2. Eye&Head

> E. Cardillo, G. Sapienza, C. Li and A. Caddemi, "Head Motion and Eyes Blinking Detection: a mm-Wave Radar for Assisting People with Neurodegenerative Disorders," *2020 50th European Microwave Conference (EuMC)* , 2021, pp. 925-928, doi: 10.23919/EuMC48046.2021.9338116.

.3. Throat

- **voice recognition**

> Xu, Chenhan, et al. "Waveear: Exploring a mmwave-based noise-resistant speech sensing for voice-user interface." *Proceedings of the 17th Annual International Conference on Mobile Systems, Applications, and Services* . 2019. [**pdf**]

- **voice identity**

> Li, Huining, et al. "VocalPrint: exploring a resilient and secure voice authentication via mmWave biometric interrogation." *Proceedings of the 18th Conference on Embedded Networked Sensor Systems* . 2020. [**pdf**]

.4. Breath

> H. Zhao et al., "A Noncontact `Breathing Disorder Recognition` System Using 2.4-GHz Digital-IF Doppler Radar," in IEEE Journal of Biomedical and Health Informatics, vol. 23, no. 1, pp. 208-217, Jan. 2019, doi: 10.1109/JBHI.2018.2817258. [**pdf**]

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X. Ma, Y. Wang, X. You, J. Lin, and L. Li, “ `Respiratory pattern recognition` of an adult bullfrog using a 100-GHz CW Doppler radar transceiver,” inProc. IEEE MTT-S Int. Microw. Biomed. Conf., 2019,pp. 1–3.

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J. Tu, T. Hwang, and J. Lin, “ `Respiration rate measurement` under 1-D body motion using single continuous-wave Doppler radar vital sign detection system,”IEEE Trans. Microw. Theory Techn., vol. 64, no. 6,pp. 1937–1946, Jun. 2016.

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Cardillo, Emanuele, Changzhi Li, and Alina Caddemi. "Vital Sign Detection and Radar Self-Motion Cancellation Through Clutter Identification." *IEEE Transactions on Microwave Theory and Techniques* 69.3 (2021): 1932-1942. [**pdf**]

.5. Cardiac motion&Blood pressure

H. Zhao, X. Gu, H. Hong, Y. Li, X. Zhu, and C. Li, “Non-contact `beat-to-beat blood pressure measurement` using continuous waveDoppler radar,” inIEEE MTT-S Int. Microw. Symp. Dig., Jun. 2018,pp. 1413–1415.

. Saluja, J. Casanova, and J. Lin, “A supervised machine learning al-gorithm for heart-rate detection using Doppler motion-sensing radar,”IEEE J. Electromagn. RF Microw. Med. Biol., vol. 4, no. 1, pp. 45–51,Mar. 2020.VOLUME 1, NO. 1, JANUARY 202177

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. Hui, T. B. Conroy, and E. C. Kan, “ `Multi-point` near-field `RF sensing` of `blood pressures` and `heartbeat dynamics`,”IEEE **Access**,vol. 8, pp. 89935–89945, 2020.

.4. Demo

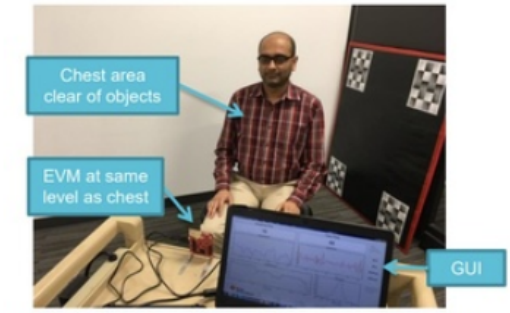
> 生命体征就是用来判断病人的病情轻重和危急程度的指征。主要有 心率、脉搏、血压、呼吸、疼痛、血氧、瞳孔和角膜反射的改变 等等。正常人在安静状态下，脉搏为60—100次/分（一般为70—80次/分）。当心功能不全、休克、高热、严重的贫血和疼痛、 **甲状腺危象** 、心肌炎，以及阿托品等药物中毒时，心率和脉搏显著加快。当 **颅内压增高** 、 **完全性房室传导阻滞** 时，脉搏减慢。在一般情况下心率与脉搏是一致的，但在 **心房颤动** 、频发性 **早搏** 等 **心律失常** 时，脉搏会少于心率，称为 **短绌 脉** 。
>
> - 生命四大体征包括 **呼吸** 、 **体温** 、 **脉搏** 、 **血压** ，医学上称为四大体征。

利用毫米波雷达实现呼吸、心跳检测，无论是CW模式还是FMCW模型，其原理都是检测呼吸心跳所引起胸腔表面的振动位移。

$$s_r(t) = \sigma(t)\exp\left(j\left[\frac{4\pi}{\lambda}x(t) + \varphi\right]\right)$$

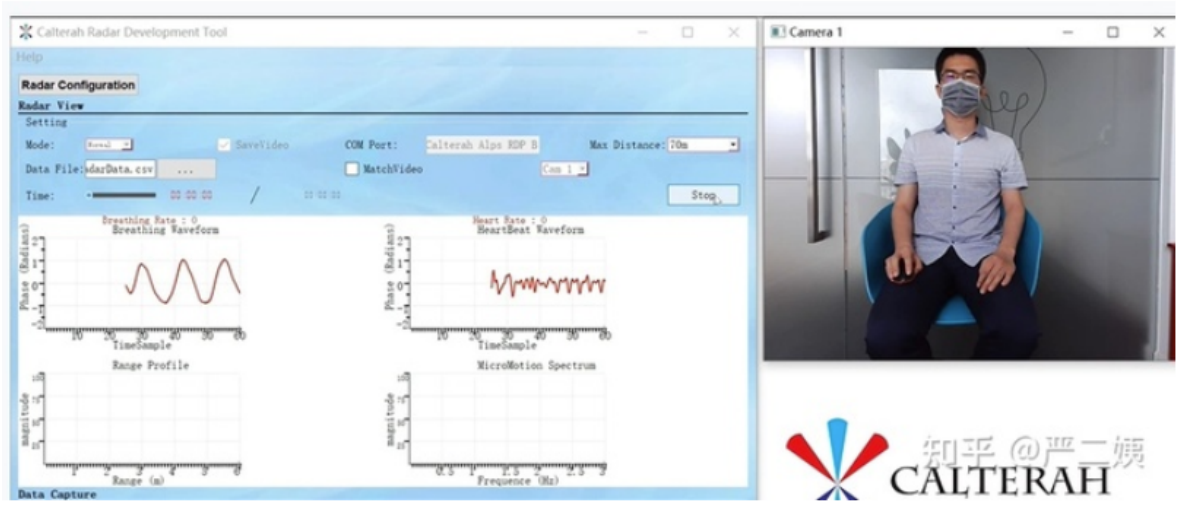
其中， $x(t) = x_r(t) + x_c(t)$ ，分别为呼吸和心跳引起的胸腔振动。

.1. TI 德州仪器



Note: Although not an absolute requirement, a lens in front of the sensor will improve the performance

.2. 加特兰 [code]

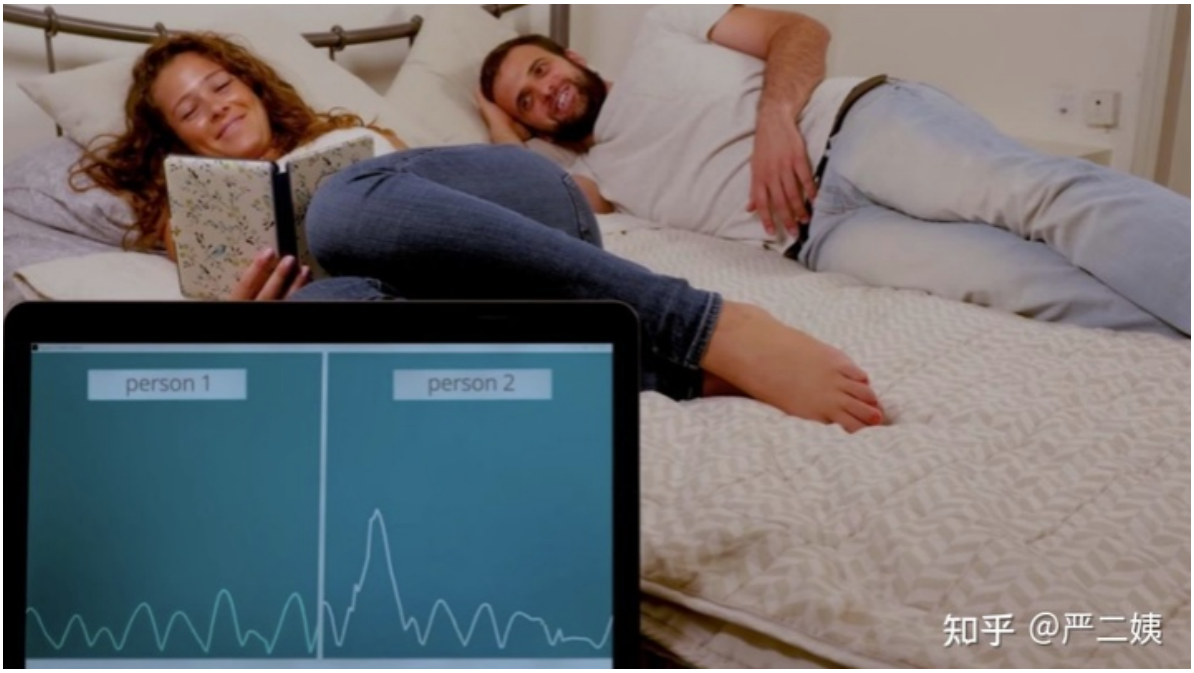


.3. IMEC 微电子研究中心

> Experiments have demonstrated the sensor's ability for `multi-target detection`, `heartbeat detection at 5 meter` and accurate tracking of a pedestrian's position and velocity.

.4. Vayyar

> Future Features Holisitic health and safety monitoring.



.5. Vayyar Home

> Vayyar's intelligent sensors `monitor location, posture as well as vital signs`, enabling behavioral monitoring such as `time spent at rest`, `in and out of bed`, `nocturnal roaming`, and `restroom visits.` Trends are detected, allowing for pre-emptive predictions of health conditions such as UTI, dementia, and disorders like sleep apnea and psychological ailments including loneliness.
>
> - Real-time fall detection
> - Rich activity data collection
> - Robust sensing in all conditions
> - Maintains privacy

- Unobtrusive installation

.6. Fall Detection

elloh755 Merge branch 'master' of https://github.com/elloh755/Fall-Detection-w... ... 4eabe42 on 25 Apr 2020 10 commits

.gitignore	ignored the local readme	14 months ago
Data_Collect.py	Initial Commit	14 months ago
Fall_RasterImage.csv	Collected Data	14 months ago
Fall_Targets.csv	Collected Data	14 months ago
README.md	Create README.md	14 months ago
Stand_RasterImage.csv	Collected Data	14 months ago
Stand_Targets.csv	Collected Data	14 months ago
Walk_RasterImage.csv	Collected Data	14 months ago
Walk_Targets.csv	Collected Data	14 months ago
send_sms.py	added sample sms	13 months ago

.7. Tracking

加特兰毫米波雷达室内人员检测与跟踪应用是基于60GHz/77GHz毫米波雷达芯片研发，采用FMCW、MIMO等技术，具有距离精度高、速度精度高、角度分辨率高及虚警率低等优点，可以实现室内情况下对人员的准确检测、精确定位和稳定跟踪，并有效分类人与非人物体，统计室内人员个数，稳定输出人员的距离、速度和角度等信息。