Modern SoCs for Consumer Robotics and AIoT

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Trifo – an AI home robot company

2016
Foundation
• Founded in Silicon Valley, CA
• A genuine AI home robot company

2017
Ironsides
B2B Model
• Visual Inertial Computing Module for various robotics applications

2018
Ironpie
1st Robot Vacuum
• Smart navigation system

Jan 2020
Max
Home Surveillance Robot Vacuum
• Advanced surveillance feature with motion and audio detection
• 2-way speaker/mic to enhance human-robot interaction
• VSLAM & multiple sensor fusion

Mar 2020
Emma
Entry-level Robot Vacuum
• Smart navigation
• More powerful suction and battery life

May 2020
Lucy
1st generation AI home robot
• Obstacle recognition and avoidance
• Smart room recognition & segmentation
• Day/night surveillance capabilities

Q4 2020
Trifo Home+
AI home robot ecosystem
• Rich hardware/software extensions based on Lucy
Home robots & AIoT are merging.
- Flexible core functionalities for fast product integration
  - The processor needs to provide the computing power in a flexible way for the core functionalities.

- Fully optimized for each application
  - The processor needs to have the flexibility for various applications.

- Hardware/software co-design
  - The processor design needs to consider the future software running on it.

- Accurate factory calibration
  - Hardware scalability

- State-of-the-art proprietary algorithms
  - Algorithm-driven chip design sounds crazy but it might make sense.

- Highly optimized implementation
  - SSE / NEON / CUDA
  - Accelerate deep learning on HAL
Extension & Communication
- peripheral products for different family members: elder, men/women, children, pets
- customized applications for specific functions

Cloud AI
- deep learning on cloud: advanced training and inference services
- user management: basic information, home data, customized service access/integration

Edge AI (edge computing power for the processor)
- 3D geometry: SLAM, room reconstruction, obstacle avoidance
- scene understanding: obstacle/object/room/human recognition/classification
- decision: unknown environment exploration, global planning, local navigation

Run-Time (RTOS or not, is a question for the processor)
- run-time: low latency, smart dynamic resource allocation
- deep optimization: instruction set level optimization, hardware acceleration

Hardware
- specially made chassis
- customized “eyes”
- customized “brain”
“Robotics SoC” is ...

- Microcontroller: ARM Cortex-M
- Real-time: ARM Cortex-R (depending on the need of real-time)
- Application: ARM Cortex-A (32-bit and 64-bit)
- High-end SoC with “NPU” or “edge AI chip”
  - Nvidia Jetson AGX Xavier
  - Qualcomm Robotics RB3
  - Intel RealSense + Movidius
“Robotics SoC” does …?

• Microcontroller: the most energy-efficient embedded devices

• Real-time: reliable mission-critical performance

• Application: supreme performance at optimal power

• High-end SoC with “NPU” or “edge AI chip”: AI specific computing needs
• SLAM global optimization is hard to parallelize so GPU is not quite useful.
  • SLAM has a lot of “if-else” logic in real product.
  • The sparse matrix operations in SLAM optimization can’t be easily parallelized.

• Run-Time performance is super important and impacts algorithm performance.

• Real product’s SLAM system always has hardware dependency.
  • In a robotic system, sensing highly depends on sensors.
  • The perception/decision in a robotic system will adapt accordingly.
Take a robotic system with SLAM functionality as an example

- Is it a demo or a product? (no joking at all)
- User experience & application scenario decide your SLAM & chip choice.
- Which is more important in SLAM, “L” (localization) or “M” (mapping)?
- What is your BOM budget for sensors and chips?
- What is more important, perfect performance or robustness with some perf sacrifice?
- Does the robotic system need deep learning capabilities?
- “Hey we are talking about chips, why do you have so many questions for those other things?”
- “Because it matters.”
• GPU helps A LOT!

• A lot of work has been done by framework provider.

Intel VisionAccelerator with Movidius Myriad X VPUs
Challenges!

• Not designed for robotics
  • real-time performance: Real-time is not fastness, but guaranteed timing.
  • hardware synchronization: It is key to sensor fusion, but few SoCs have such design.
  • computation resource: Parallel computing and deep network acceleration is not the whole thing.

• Not enough tech support
  • To support sensors (sensor itself, driver, perf tuning) need SoC makers’ support.
  • Run-time performance is equally important as innovative algorithms themselves.

• End-to-end is soooo hard: technology->product & product cycle
• Advanced integrated SoCs are showing up.
  • Nvidia Jetson AGX Xavier
  • Qualcomm Robotics RB3
  • Intel RealSense + Movidius
  • NXP, Rockchip, Allwinner

• High-tech commoditization is accelerating.
  • Smartphone supply chain has been benefiting other smart hardware.
  • Consumer electronics drives the mainstreaming of technologies.

• Consumer Robotics and AIoT is happening.
  • SoC chips are essential to consumer robotics and AIoT. We are still in quite an early stage.