BLM4021 Gömülü Sistemler

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Yıldız Teknik Üniversitesi – Bilgisayar Mühendisliği

Sunum 1 – Gömülü Sistemlere Giriş

- Dersle ilgili genel bilgilendirme
- Önerilen Kaynaklar
- Giriş
- Mikroişlemci, mikrodenetleyici ve gömülü sistem kavramları
- Tasarım yapılırken dikkat edilecekler

Genel Bilgilendirme

Ders Adı	Kodu	Yerel Kredi	AKTS	Ders (saat/hafta)	Uygulama (saat/hafta)	Laboratuar (saat/hafta)
Gömülü Sistemler	BLM4021	3	4	2	0	2

Değerlendirme Sistemi

Etkinlikler	Sayı	Katkı Payı
Devam/Katılım		
Laboratuar		
Uygulama		
Arazi Çalışması		
Derse Özgü Staj		
Küçük Sınavlar/Stüdyo Kritiği		
Ödev		
Sunum/Jüri		
Projeler	1	30
Seminer/Workshop		
Ara Sınavlar	1	30
Final	1	40
Dönem İçi Çalışmaların Başarı Notuna Katkısı		60
Final Sınavının Başarı Notuna Katkısı		40
TOPLAM		100

Ders Materyalleri

Gerekli Kaynaklar:

- Derek Molloy, Exploring Raspberry Pi: Interfacing to the Real World with Embedded Linux, Wiley, 2016.
- M. Wolf, Computers as Components: Principles of Embedded Computing System Design, Elsevier, 2008.

Yardımcı Kaynaklar:

- P. Membrey, D. Hows, Learn Raspberry Pi 2 with Linux and Windows 10, Apress, 2015.
- F. Vahid, T. Givargis, Embedded System Design, 1999.
- P. Koopman, Better Embedded Systems Software, Drumadrochit Education Pub., 2010.
- O. Urhan, Gömülü Sistem Lisansüstü Ders Notları, 2018.
- P. Jones, Embedded Systems Design, CPRE488 Lecture Notes, IOWA State University.

Haftalık Konular

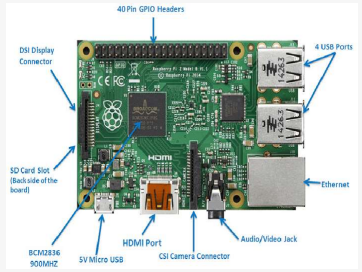
Hafta	Teorik	Laboratuvar
1	Giriş ve Uygulamalar, Mikroişlemci, Mikrodenetleyici ve Gömülü sistem kavramlarının açıklanması	Grupların oluşturulması & Kitlerin Testi
2	Bir Tasarım Örneği, Mikroişlemci, Mikrodenetleyici, DSP, FPGA, ASIC kavramları	Kitlerin gruplara dağıtımı + Raspberry Pi Kurulumu
3	16, 32 ve 64 bitlik mikrodenetleyiciler, pipeline	Raspberry Pi ile Temel Konfigürasyon
4	PIC ve MSP430 özellikleri	Uygulama 1 – Raspberry Pi ile Buzzer Uygulaması
5	ARM ve RISC-V tabanlı mimariler ve özellikleri	Uygulama 2 – Raspberry Pi ile Ivme ve Gyro Uygulaması
6	ARM Komut setleri ve Assembly Kodları-1	Uygulama 3 – Raspberry Pi ile Motor Kontrol Uygulaması
7	ARM Komut setleri ve Assembly Kodları-2, Raspberry Pi vers. ve GPIO'ları	Uygulama 4 – Raspberry Pi ile Görüntü İşleme Uygulaması
8	*Vize Sınavı*	
9	Çoklu ortam algılayıcıları ve arayüzleri (SPIE, I2C…)	Uygulama 5 – Raspberry Pi ile Network Uygulaması
10	Sensörlerden Veri Toplama, Algılayıcı, ADC ve DAC	Proje Soru-Cevap Saati
11	Zamanlayıcı, PWM ve Motor Sürme	Proje kontrolü-1
12	Gerçek Zaman Sistemlerinde temel kavramlar	Proje Kontrolü-2
13	Gerçek zaman İşletim Sistemleri	Mazeret sebepli son proje kontrollerinin yapılması
14	Nesnelerin İnterneti	
15	*Final Sınavı*	

For more details -> Bologna page: http://www.bologna.yildiz.edu.tr/index.php?r=course/view&id=9463&aid=3

Google Classroom Linki https://classroom.google.com/c/NTQ5ODIxNDg3OTI4?cjc=cbftudx

Projeler

- Çoğunlukla Raspberry Pi Rev 2 Model B (UK) ile yapılacaktır.
- Projelerin zorluk seviyesi orta seviyede olacaktır.
- 3 veya 4'er kişilik gruplar halinde yapılacaktır.
- Her grup tarafından kararlaştırılan proje konusu en geç 4. hafta sonuna kadar Google Docs'a girilmelidir.
- Proje sunumları en geç 12. hafta tamamlanacaktır.



Lab. İzlencesi

Google Classroom Linki https://classroom.google.com/c/NTQ5ODIxNDg3OTI4?cjc=cbftudx

Lab. Sorumlusu:

Arş. Gör. Burak Ahmet ÖZDEN

Arş. Gör. Mustafa CEBECİ

Arş. Gör. Ömer Mutlu Türk KAYA

Hafta	Laboratuvar
1	Grupların oluşturulması & Kitlerin Testi
2	Kitlerin gruplara dağıtımı + Raspberry Pi Kurulumu
3	Raspberry Pi ile Temel Konfigürasyon
4	Uygulama 1 – Raspberry Pi ile Buzzer Uygulaması
5	Uygulama 2 – Raspberry Pi ile Ivme ve Gyro Uygulaması
6	Uygulama 3 – Raspberry Pi ile Motor Kontrol Uygulaması
7	Uygulama 4 – Raspberry Pi ile Görüntü İşleme Uygulaması
8	Vize
9	Uygulama 5 – Raspberry Pi ile Network Uygulaması
10	Proje Soru-Cevap Saati
11	Proje kontrolü-1
12	Proje Kontrolü-2
13	Mazeret sebepli son proje kontrollerinin yapılması

*16 Ekim tarihine kadar grupları belirlemeniz gerekiyor.
*23 Ekim tarihine kadar ise projeleri belirlemeniz gerekli.

Örnek Proje Konuları – Raspberry Pi

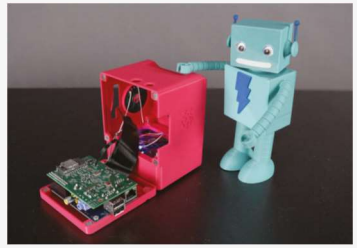
- Webcam üzerinden OpenCV ile bir görüntü işleme uygulaması (örn. Kenar bulma, Yüz tespiti)
- USB mikrofon üzerinden ses tespit veya tanıma uygulaması
- Akıllı ev otomasyonu (örn. Butonlar ile uzaktaki bir ışığı/motoru açıp kapama)
- Mini meteoroloji istasyonu (nem, sıcaklık ve basınç bilgilerinin ölçülmesi ve arayüzde gösterilmesi, sıcaklık artışında uyarı)
- Otonom robot (duvara çarpmadan hareket edebilen bir robot -> powerbank)
- Analog Joystick ile oyun tasarımı ve her galibiyette sesli uyarı

Projeler

Raspberry Pi	Modelo A	Modelo A+	Modelo B	Modelo B+	RPI V2 modelo B	RPI 3 modelo B
SoC	Broadcom BCM2835	Broadcom BCM2835	Broadcom BCM2835	Broadcom BCM2835	Broadcom BCM2836	Broadcom BCM2837
CPU	700MHz ARM1176JFZ-S	700MHz ARM1176JFZ-S	700MHz ARM1176JFZ-S	700MHz ARM1176JFZ-S	900MHz Quad-core ARM Cortex-A7	1.2Ghz Quad Cortex A53
GPU	VideoCore IV	VideoCore IV	VideoCore IV	VideoCore IV	250Mhz VideoCore IV	400Mhz VideoCore IV
RAM	256Mb	512Mb	512Mb	512Mb	1Gb	1Gb
USB	1	1	2	4	4	4
Video	RCA, HDMI	Jack, HDMI	RCA, HDMI	Jack, HDMI	Jack, HDMI	Jack, HDMI
Audio	Jack, HDMI	Jack, HDMI	Jack, HDMI	Jack, HDMI	Jack, HDMI	Jack, HDMI
Boot	Memoria SD	Memoria microSD	Memoria SD	Memoria microSD	Memoria microSD	Memoria microSD
Wireless	No tiene	No tiene	No tiene	No tiene	No tiene	802.11n / Bluetooth 4.1
Red Ethernet	No tiene	No tiene	Ethernet 10/100	Ethernet 10/100	Ethernet 10/100	Ethernet 10/100
Alimentación	5V / 2Amp	5V / 2Amp	5V / 2Amp	5V / 2Amp	5V / 2Amp	5V / 2,5Amp
GPIO	26 pines GPIO	40 pines GPIO	26 pines GPIO	40 pines GPIO	40 pines GPIO	40 pines GPIO
Tamaño	85,6 x 53,98 mm	65 x 56 mm	85,6 x 53,98 mm	85 x 56 x 17 mm	85 x 56 x 17 mm	85 x 56 x 17 mm

Projeler başka neler olabilir?

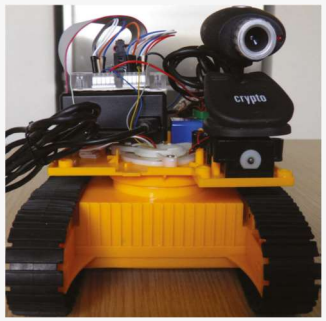
MAC Mini Pi



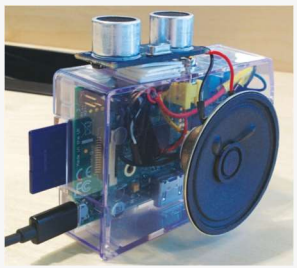
Projeler başka neler olabilir?

Magic Mirror

Remote Controlled SPY Rover

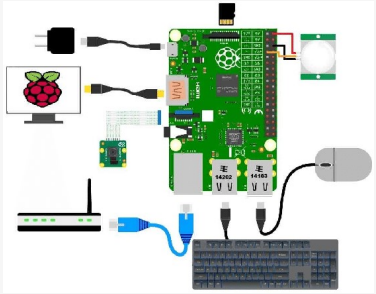


Ultrasonic Theremin



Raspberry Pi ile çalışmak için gerekenler

1. Raspberry Pi Model B & Raspberry Pi 2 Model B (Laboratuvarımızda var.)
2. En az 2A'lik bir güç adaptörü (Laboratuvarımızda var.)
3. Mikro USB kablo
4. MicroSD kart (8-32 GB)
5. HDMI ekran kablosu
6. Monitor, klavye ve Mouse
7. Ethernet kablosu



Gömülü Sistemler (Embedded Systems)

Daha büyük bir ürün içerisine gömülen bilgi işleme sistemleri olarak tanımlanmaktadır.

Alan kişilerin alma nedeni, bilgi işlemesi değil ☺

An **embedded system** is simultaneously:

1. "a digital system that provides service as part of a larger system" – *G. De Micheli*
2. "any device that includes a programmable computer but is not itself a general-purpose computer" – *M. Wolf*
3. "a less visible computer" - *E. Lee*
4. "a single-functioned, tightly constrained, reactive computing system" – *F. Vahid*
5. "a computer system with a dedicated function within a larger mechanical or electrical system, often with real-time computing constraints" – *Wikipedia*

Jones, Spring 2019 © ISU | CprE 488 (Introduction) | Lect-01.4

Uygulama Alanları

- Ulaşım araçları (tren, uçak, iha, arabalar vb.)
- Haberleşme sistemleri (3G, 4G, 5G, telsiz iletişimi, uydu haberleşmesi vb.)
- Medikal sistemler (tansiyon aleti, yapay göz, EKG, EMG vb. cihazlar)
- Askeri uygulamalar (sualtı araçlar, sihalar vb.)
- Tüketici elektroniği (televizyon, fotoğraf makinası, saat, çamaşır makinesi vb.)
- Robotik, Akıllı Binalar, Fabrika Ekipmanları, Alarm Sistemleri, Video Oyunları …

Birkaç Örnek…

Information Technology

Pedometer

- Obvious computer work:
  - Count steps
  - Keep time
  - Averages
  - etc.
- Hard computer work:
  - Actually identify when a step is taken
  - Sensor feels motion of device, not of user feet

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Birkaç Örnek…

Information Technology

Mobile phones

- Multiprocessor
  - 8-bit/32-bit for UI
  - DSP for signals
  - 32-bit in IR port
  - 32-bit in Bluetooth
- 8-100 MB of memory
- All custom chips
- Power consumption & battery life depends on software

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Birkaç Örnek…

Information Technology

Mobile base station

- Massive signal processing
  - Several processing tasks per connected mobile phone
- Based on DSPs
  - Standard or custom
  - 100s of processors

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Birkaç Örnek…

Mars Sojourner Rover (1997)
- About 25 pounds
- 25 x 19 x 12 inches
- 8-bit Intel 80C85
  - 100 KHz

Opportunity/ Spirit (2004)
- About 400 pounds
- 5.2 x 7.5 x 4.9 ft
- 32-bit Rad6000
  - 20 MHz
  - cost: ??

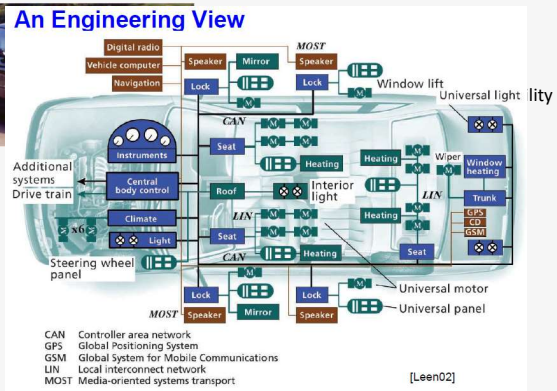
Arabalar

- Many of today's cars operate with over 100 million lines of code. A high-end automobile may have 100 microprocessors, but even inexpensive cars.
- Today use 40 microprocessors. Some of these microprocessors do very simple things such as detect whether seat belts are in use. Others control critical functions such as the ignition and braking systems.

ABS, ESP, Airbag, Automatic gearboxes, blind-angle alert system…

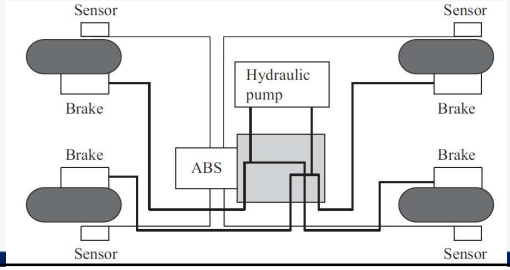
- Large diversity in processor types:
  - 8-bit – door locks, lights, etc.
  - 16-bit – most functions
  - 32-bit – engine control, airbags

Arabalar



Örnek : ABS ve ASC+T

Consider the ABS. The purpose of an ABS is to temporarily release the brake on a wheel when it rotates too slowly—when a wheel stops turning, the car starts skidding and becomes hard to control. It sits between the hydraulic pump, which provides power to the brakes, and the brakes themselves as seen in the accompanying diagram. This hookup allows the ABS system to modulate the brakes to keep the wheels from locking. The ABS system uses sensors on each wheel to measure the speed of the wheel. The wheel speeds are used by the ABS system to determine how to vary the hydraulic fluid pressure to prevent the wheels from skidding.



Örnek : ABS ve ASC+T

The ASC+T system's job is to control the engine power and the brake to improve the car's stability during maneuvers. The ASC+T controls four different systems: throttle, ignition timing, differential brake, and (on automatic transmission cars) gear shifting. The ASC+T can be turned off by the driver, which can be important when operating with tire snow chains.

The ABS and ASC+T must clearly communicate because the ASC+T interacts with the brake system. Since the ABS was introduced several years earlier than the ASC+T, it was important to be able to interface ASC+T to the existing ABS module, as well as to other existing electronic modules. The engine and control management units include the electronically controlled throttle, digital engine management, and electronic transmission control. The ASC+T control unit has two microprocessors on two printed circuit boards, one of which concentrates on logic-relevant components and the other on performance-specific components.

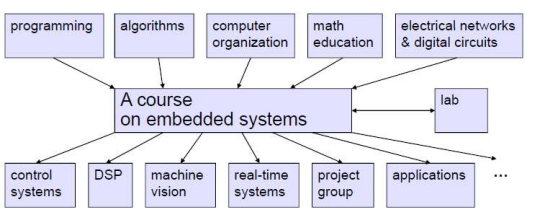
https://www.youtube.com/watch?v=evMgG-poSX8

Embedded Systems for Kids

- Lego Mindstorm Robotics Kit

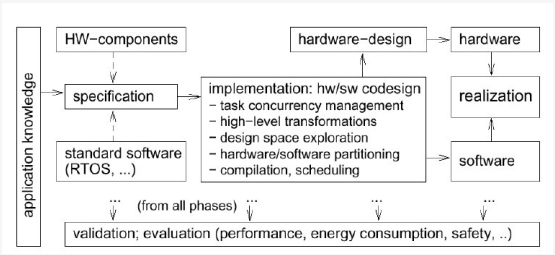
8-bit processor, 64 kByte memory

Gömülü Sistem Konsepti

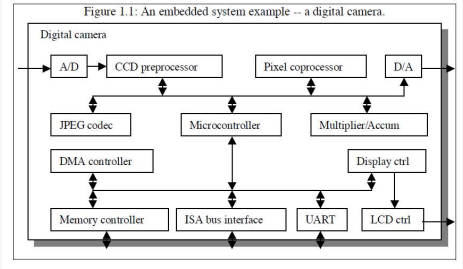


- Provides motivation and context of other work in the area
- Mix of students and courses from CS and EE departments

Gömülü Sistem Konsepti



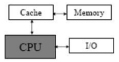
Dijital Kamera Örneği



Computer Eng. & Embedded Computer Designer

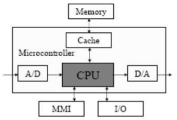
Computer Engineers:

- Measured by: Performance, Cost
  Compilers & OS matters



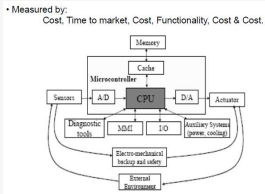
Embedded Computer Designers:

- Measured by: Cost, I/O connections, Memory Size, Performance



Embedded Control System Designers:

- Measured by:
  Cost, Time to market, Cost, Functionality, Cost & Cost.



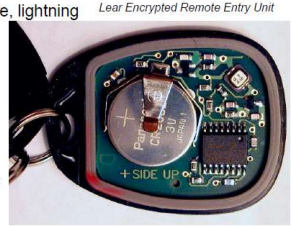
Embedded System Designer Skill Set

- Appreciation for multidisciplinary nature of design
  - Both hardware & software skills
  - Understanding of engineering beyond digital logic
  - Ability to take a project from specification through production
- Communication & teamwork skills
  - Work with other disciplines, manufacturing, marketing
  - Work with customers to understand the real problem being solved
  - Make a good presentation; even better write ``trade rag" articles
- And, by the way, technical skills too...
  - Low-level: Microcontrollers, FPGA/ASIC, assembly language, A/D, D/A
  - High-level: Object oriented Design, C/C++, Real Time Operating Systems
  - Meta-level: Creative solutions to highly constrained problems
  - Likely in the future: **U**nified **M**odeling **L**anguage, embedded networks

Typical Embedded System Constraints

- **Small Size, Low Weight**
  - Hand-held electronics
  - Transportation applications -- weight costs money
- **Low Power**
  - Battery power for 8+ hours (laptops often last only 2 hours)
  - Limited cooling may limit power even if AC power available
- **Harsh environment**
  - Power fluctuations, RF interference, lightning
  - Heat, vibration, shock
  - Water, corrosion, physical abuse
- **Safety-critical operation**
  - Must function correctly
  - Must *not* function *in*correctly
- **Extreme cost sensitivity**
  - $.05 adds up over 1,000,000 units

Lear Encrypted Remote Entry Unit



Gömülü Sistemlerin Karakteristikleri

- Must be **dependable**,
  - **Reliability *R(t)* =** probability of system working correctly provided that is was working at *t*=0
  - **Maintainability *M(d)* =** the probability that a failing system can be repaired within a certain time-frame.
  - **Availability *A(t)***: probability of system working at time *t*
  - **Safety**: no harm to be caused
  - **Security**: confidential and authentic communication
- Must be **efficient**
  - Energy efficient
  - Code-size efficient (especially for systems on a chip)
  - Run-time efficient (consuming less resource)
  - Weight efficient
  - Cost efficient

- **Dedicated** towards a certain **application**
- **Dedicated user interface** (no mouse, keyboard and screen)

**O. Urhan, Gömülü Sistemler Ders slaytları

Gömülü Sistemlerin Karakteristikleri

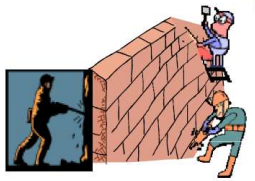
- Many ES must meet **real-time constraints**
  - A real-time system must react to stimuli from the controlled object (or the operator) within the time interval **dictated** by the environment.
  - For real-time systems, right answers arriving too late are wrong.
- Frequently **connected to physical environment** through sensors and actuators,
- **Hybrid systems** (analog + digital parts).

**O. Urhan, Gömülü Sistemler Ders slaytları

It is not sufficient to consider ES just as a special case of software engineering

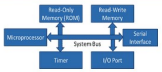
EE knowledge must be available, Walls between EE and CS must be torn down

CS EE



**O. Urhan, Gömülü Sistemler Ders slaytları

Mikroişlemciler ve Mikrodenetleyiciler

Microprocessor	Micro Controller
	
Microprocessor is heart of Computer system.	Micro Controller is a heart of embedded system.
It is just a processor. Memory and I/O components have to be connected externally	Micro controller has external processor along with internal memory and I/O components
Since memory and I/O has to be connected externally, the circuit becomes large.	Since memory and I/O are present internally, the circuit is small.

Microprocessor

- CPU is stand-alone, RAM, ROM, I/O, timer are separate
- designer can decide on the amount of ROM, RAM and I/O ports.
- expensive
- versatility
- general-purpose
- High processing power
- High power consumption
- Instruction sets focus on processing-intensive operations
- Typically 32/64 – bit
- Typically deep pipeline (5-20 stages)

Microcontroller

- CPU, RAM, ROM, I/O and timer are all on a single chip
- fixed amount of on-chip ROM, RAM, I/O ports
- for applications in which cost, power and space are critical
- single-purpose (control-oriented)
- Low processing power
- Low power consumption
- Bit-level operations
- Instruction sets focus on control and bit-level operations
- Typically 8/16 bit
- Typically single-cycle/two-stage pipeline