Watchdog

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UCSB NASA

Initial Problem Specification

[intentionally blank]

Initial Problem Specification

In short: verify an astronaut's fidelity to standard operating procedure.

Proposed Solution

A combination of three approaches:

1. Computer Vision
2. Sensor-embedded tools; IoT
3. Formalization of procedure writing

Computer Vision

- Real-time neural network-based object detection and localization
- Analyze the spatial relationships between objects to deduce semantics
- Static image analysis for deducing quality of astronaut-taken photographs

Sensor-Embedded Tools

- Active NFC glove, coupled with passive NFC tools, to reliably identify current tool in use
- IMU in glove to detect macroscopic hand motion, *e.g.* swinging a hammer
- Bluetooth beacons for user localization

Procedure Formalization

- Context-free grammar specifically for expressing procedures in a way easily mapped to sense data
- Internally represent procedures with precedence graphs, rather than lists, to only capture strictly necessary ordinal relationships

<Mission> ::= <Task>+

<Task> ::= <Record Set> | <Image Set> | <Translate>

<Record Set> ::= <Record>+

<Record> ::= <Quantify> | <Qualify> | <Sample>

<Quantify> ::= <*Verbalize*> | <*Write*>

<Qualify> ::= <*Verbalize*> | <*Write*>

<Sample> ::= <*Search*> <*Identify and Mark*> <Collect Candidates>

<Collect Candidates> ::= [<Sterilization>] <Collect>+

<Collect> ::= <*Isolate Sample*> <Image Set> <*Bag Sample*> <Record Set>

<Image Set> ::= <Image>+

<Image> ::= <Picture> | <Video>

<Picture> ::= [<*Place Guide*>] <*Take Picture*>

<Video> ::= [<*Place Guide*>] <*Take Video*>

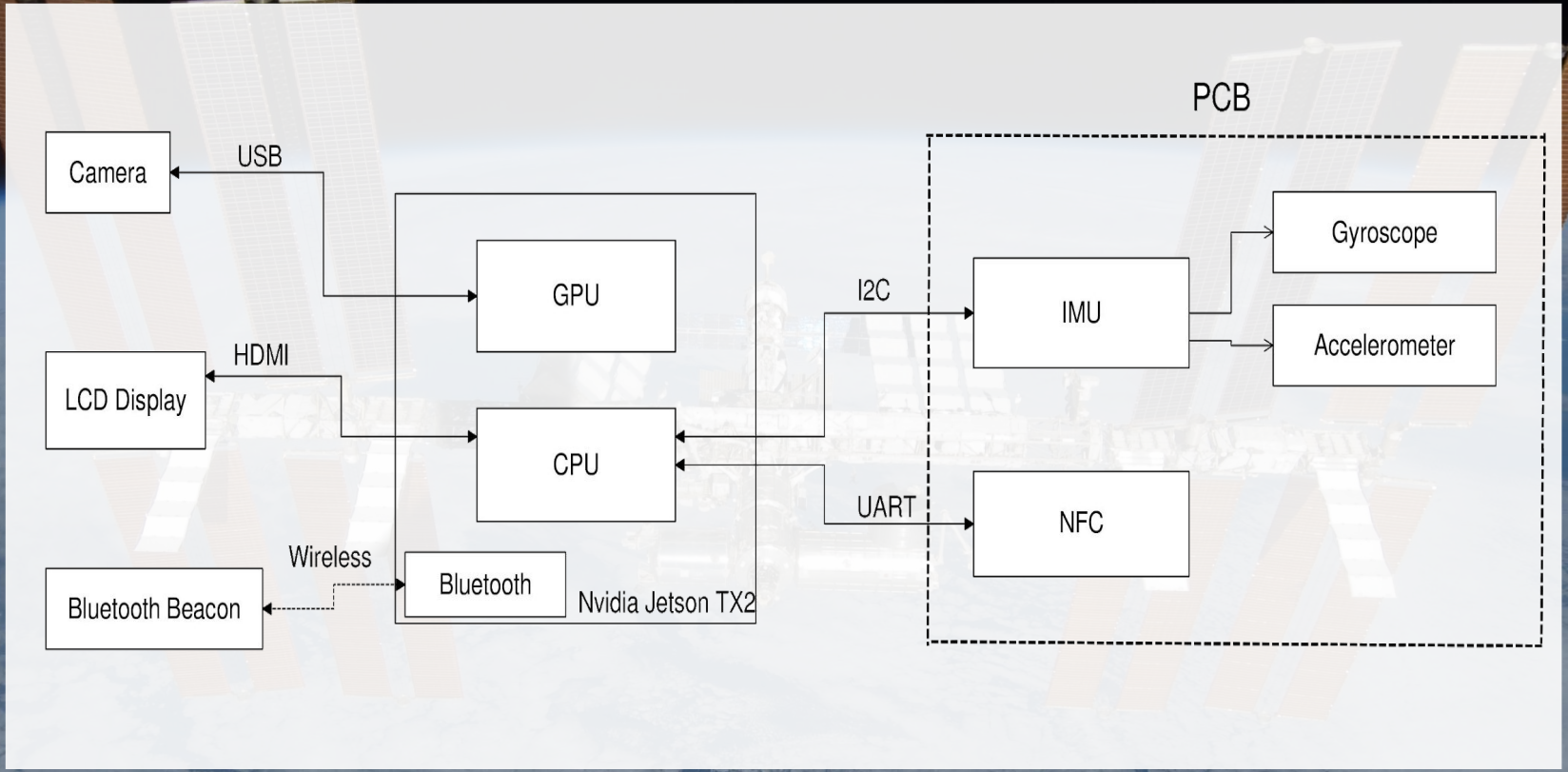
<Translate> ::= (<*Move*> [<Record Set>] [<Image Set>])+

Product Development Team

- **Ryan Lorica**: Lead, Computer Vision
- **Jingzhen Chen**: UI, IoT Algorithm Design
- **Anzhe Ye**: UI, IoT Algorithm Design
- **Jiacheng Liu**: PCB, Sensor Testing and Interfacing
- **Leo Mei**: PCB, Sensor Testing and Interfacing

* All members will cooperate for sensor fusion

High Level Block Diagram



Processor

Nvidia Jetson TX2

- ARMv8 (64-bit) Multiprocessor CPU Complex
- 256 core Nvidia Pascal GPU
- Clock speed

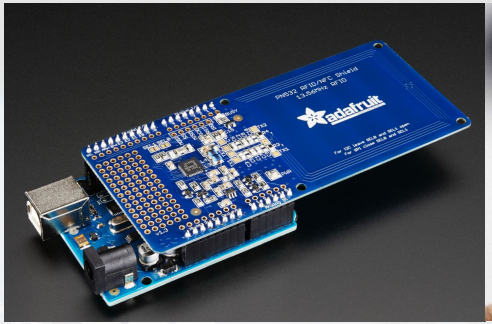
  CPU - Up to 2 GHz

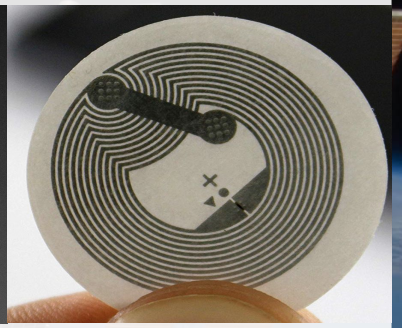
  GPU - Up to 1.3 GHz
- Power Requirement: 5.5V - 19.6V
- Peripheral Interfaces: I2C, UART, HDMI, USB
- Connectivity: Bluetooth Version 4.1

Sensors

Adafruit PN532 NFC

- Detect current using tool
- Embed NFC chip in glove, tags in tools
- Range of transmission: 10 cm
- Interface: UART





GeeekPi 5 inch LCD Touch Screen

- Display tasks and remind errors
- Resolution: 800 x 480 pixels
- Power requirement: 5V via Micro-USB
- Interface: HDMI

Sensors

Bluetooth Unit

- On-board Bluetooth Version 4.1
- Receive signal from a bluetooth beacon
  - Approach a site
- Lose signal from the bluetooth beacon
  - Leave the site

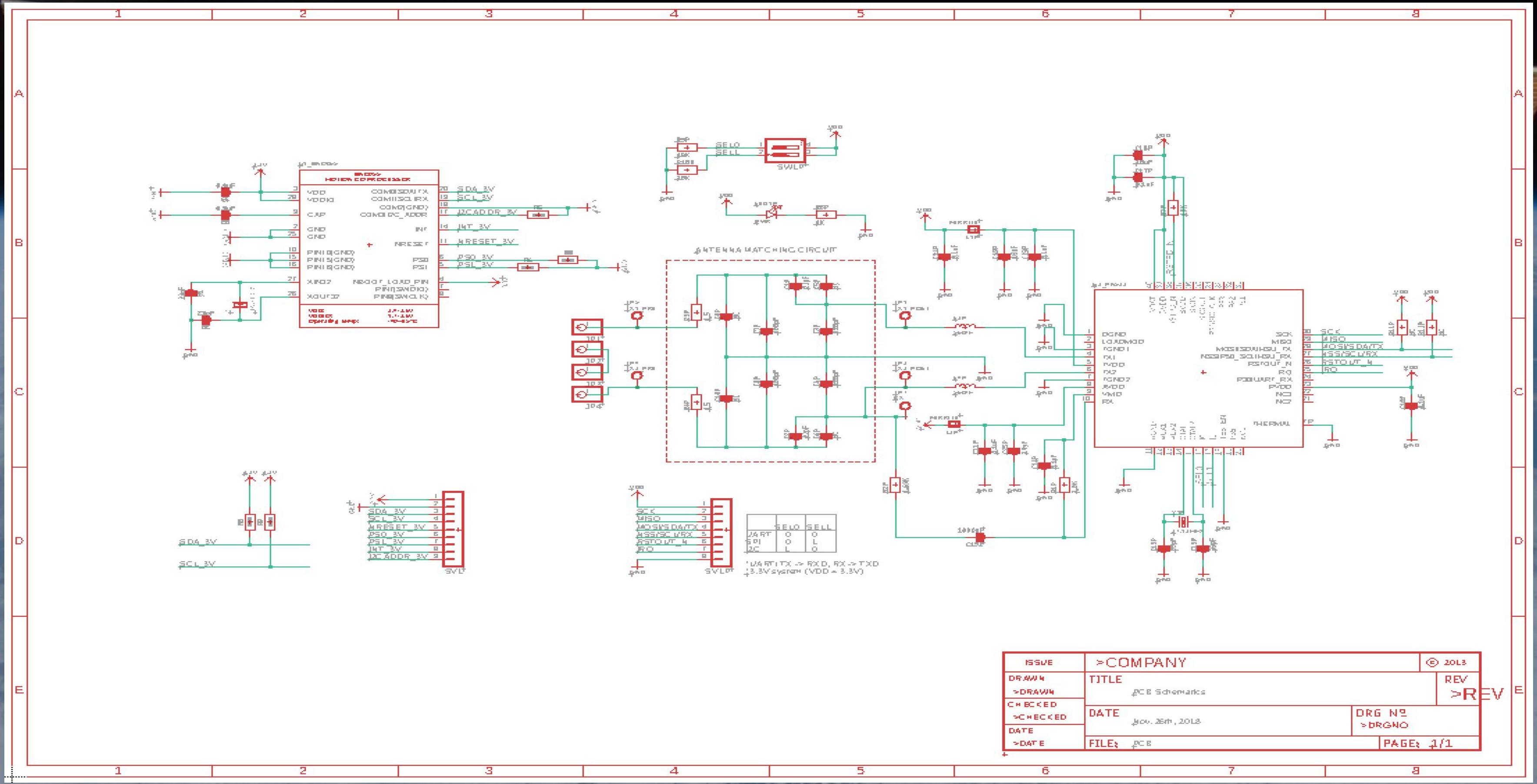
Bluetooth Beacon

- Localization
- Embed in marker
- One-way transmission
- Range of transmission: 1 m (expected)

Sensors

- Adafruit 9-dot BNO055 IMU Breakout
  - Communicates via I2C
  - Memory-mapped addressing to specify sensor, which allows for reading specific data
- Sensors used:
  - Accelerometer
    - ±2/±4/±6/±8/±16 *g* ranges.
    - Accuracy: ±60mg
    - Data rate: 100Hz
  - Gyroscope
    - ±245/±500/±2000 degree per second ranges.
    - Accuracy: ±10/±15/±75
    - Data rate: 100Hz
- Successfully tested on TX2

Schematic


ANTENNA MATCHING CIRCUIT
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© 2013
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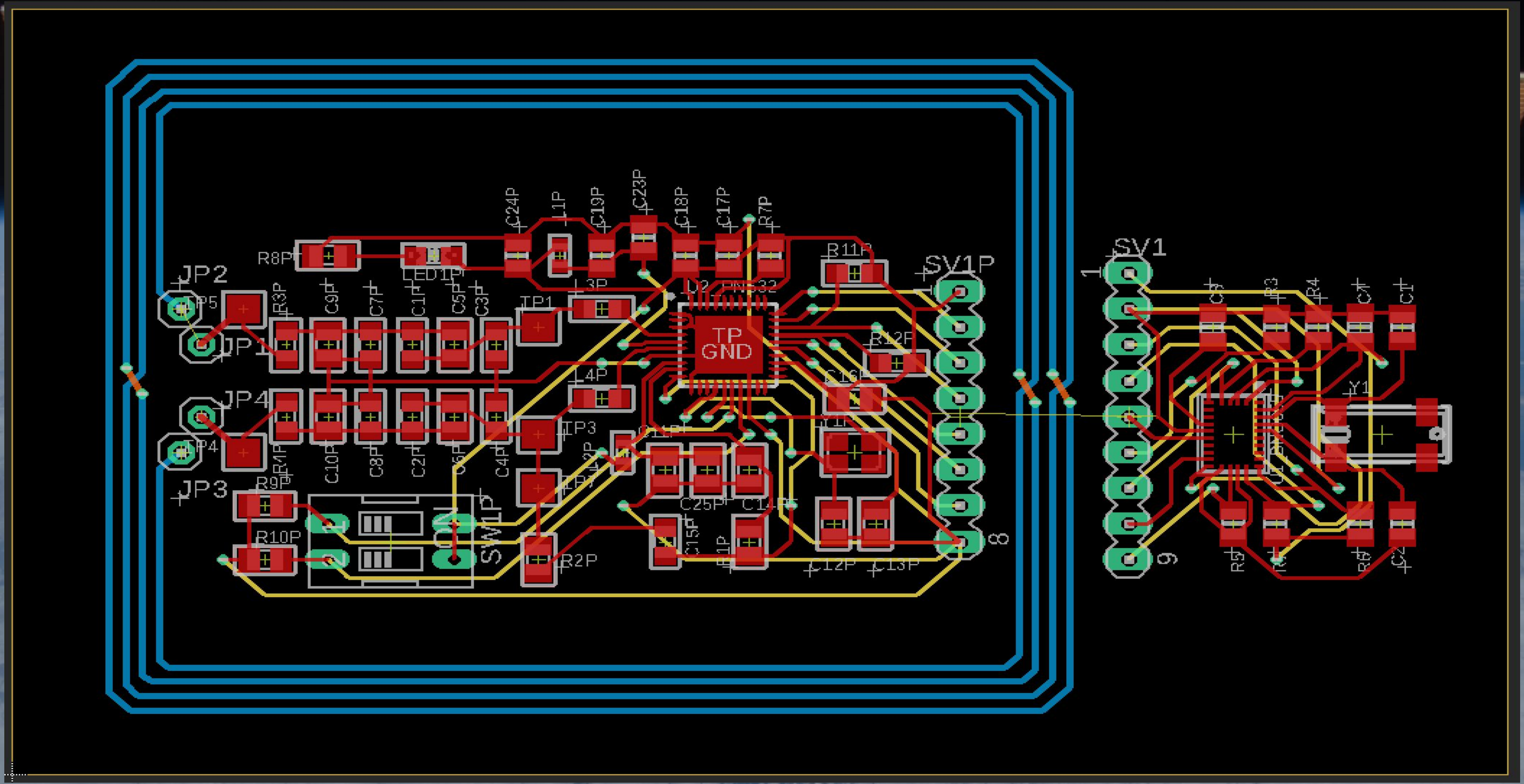
PCB

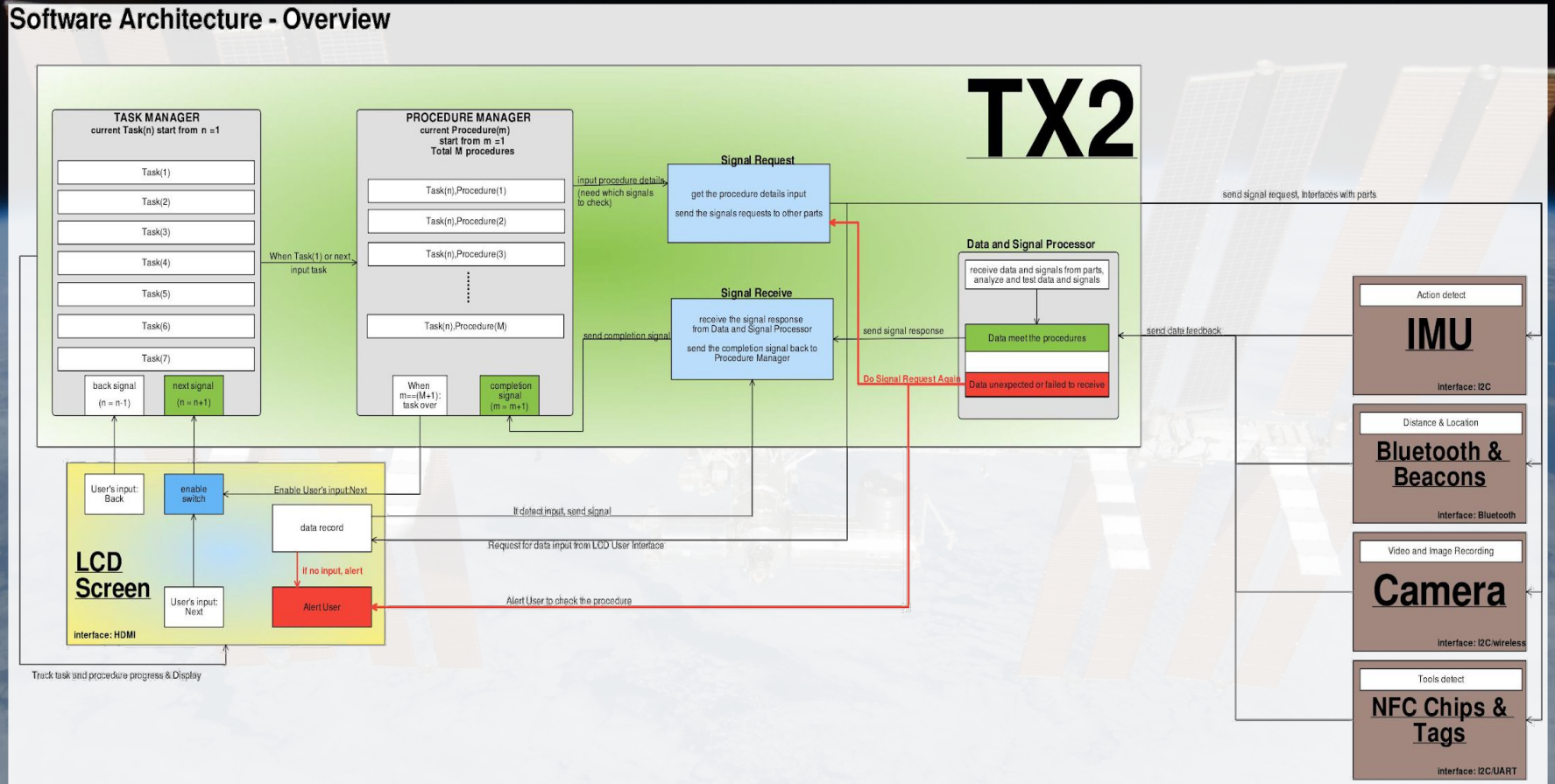


Bill of Materials

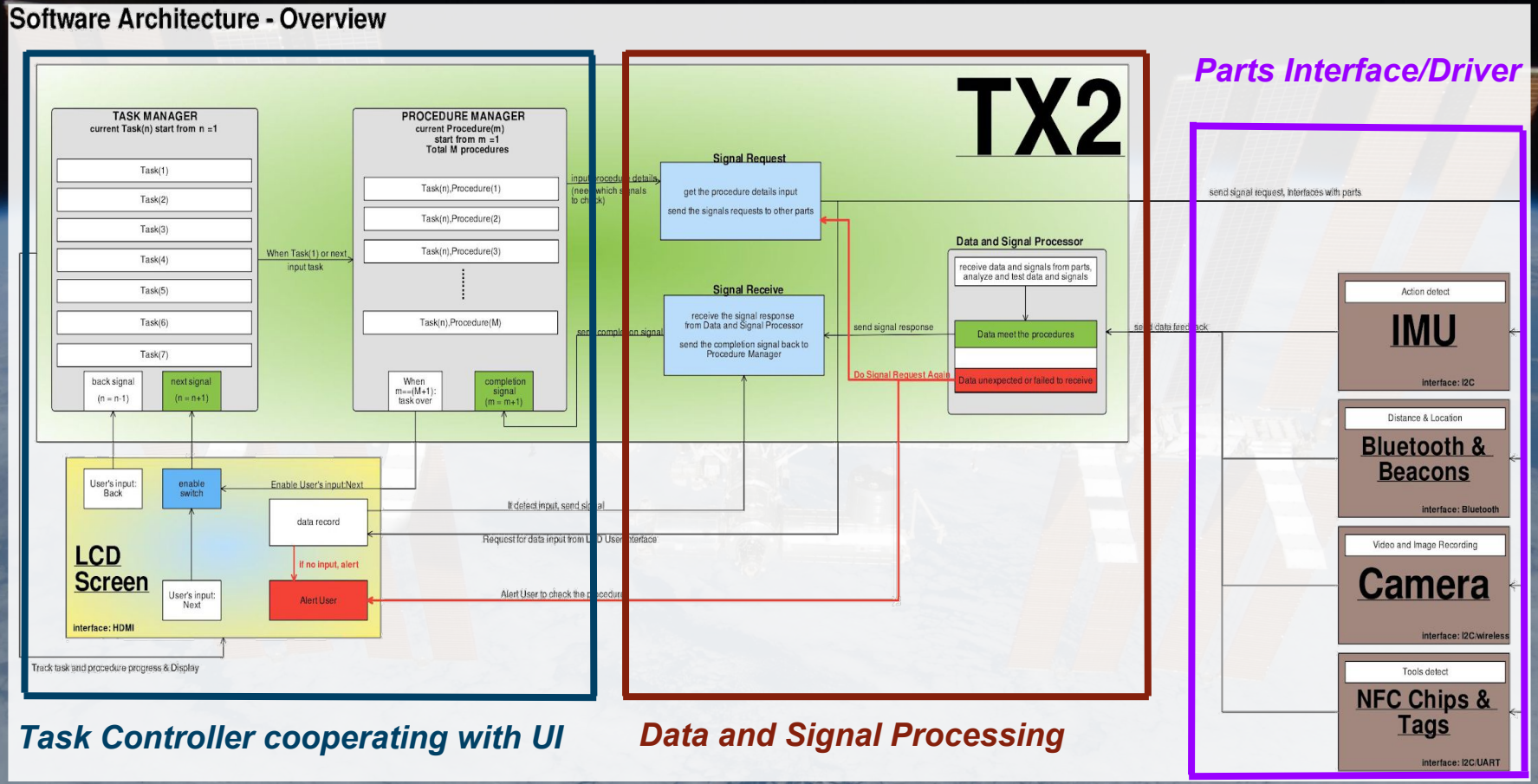
Part Label	Manufacturer	Manufacturer Part Number	Unit Price	Total Units	Total Price
Bluetooth beacon	Radius Networks	B00JJ4P864	$14	1	$14
IMU	Adafruit	BNO055	$35	1	$35
TX2	NVIDIA	945-82771-0000-000	$569.99	1	$569.99
NFC breakout	Adafruit	PN532	$42.36	1	$42.36
NFC tag	Adafruit	/	$0.70	10	$7.00
LCD display screen	Geeepi	EP-0081	$54.99	1	$54.99
Camera	Logitech	C920	$49.99	1	$49.99
				Total	$763.33

RefDes	Description	Manuf Part #	Part Order #	Vendor	Unit Price	Quantity
U1	IMU ACCEL/GYRO/MAG I2C 28LGA	BNO055	828-1058-1-ND	Digi-Key	$12.07	1
U2	NFC Chip PN532	PN5321A3HN/C106,55	771-PN5321A3HNC10	Mouser	$10.86	1
U3	IC REG LINEAR 3.3V 150MA SOT23-5	MIC5225-3.3YM5-TR	576-2980-1-ND	Digi-Key	$0.40	1
SV1	Connector Header Through Hole 9 position 0.050" (1.27mm)	GRPB091VWVN-RC	S9014E-09-ND	Digi-Key	$0.72	1
SV1P	Connector Header Through Hole 8 position 0.050" (1.27mm)	GRPB081VWVN-RC	S9014E-08-ND	Digi-Key	$0.72	1
Y1	32.768KHz Crystal	ABS25-32.768KHZ-T	535-9166-1-ND	Digi-Key	$0.63	1
Y1P	27.12MHz Crystal	ABM8-27.120MHZ-B4-T	535-13469-1-ND	Digi-Key	$0.79	1
SW1P	SWITCH SLIDE DIP SPST 25MA 24V	1571983-3	450-2128-1-ND	Digi-Key	$2.32	1
LED1P	LED RED DIFFUSED 0805 SMD	LS R976-NR-1	475-1278-1-ND	Digi-Key	$0.38	1
TP1, TP2, TP3, TP4, TP5, TP6, TP7	Test Points	5016	36-5016CT-ND	Digi-Key	$0.41	7
R6, R7	4.7KOhms Resistor	SG73G2ATTD4701D	660-SG73G2ATTD4701D	Mouser	$0.23	2
R3, R4, R5, R7P, R9P, R10P	10KOhms Resistor	SG73G2ATTD1002D	660-SG73G2ATTD1002D	Mouser	$0.23	6
R3P, R4P	1.5Ohms Resistor	CRM0805-JW-1R5ELF	652-CRM0805JW1R5ELF	Mouser	$0.10	2
R2P	1.69KOhms Resistor	ERJ-U06F1691V	667-ERJ-U06F1691V	Mouser	$0.16	1
R1P, R8P	1kOhms Resistor	SG73G2ATTD1001D	660-SG73G2ATTD1001D	Mouser	$0.23	2
R5P, R6P	Not connected, no value, use for replacement	---	---	---	---	2
C1, C2, C1P, C2P	22pF Capacitor	C0805C220F4HACAUTO	80-C0805C220F4HAUTO	Mouser	$0.31	4
C3, C4, C11P, C14P, C16P, C17P, C23P, C24P	0.1uF Capacitor	C0805C104K3RAC7210	399-7365-2-ND	Digi-Key	$0.03	8
C5P, C6P, C9P, C10P	Not connected, no value, use for replacement	---	---	---	---	4
C7P, C8P	100pF Capacitor	C0805C101FCGACTU	80-C0805C101FCG	Digi-Key	$0.48	2
C3P, C4P	220pF Capacitor	251R15S221JV4E	712-1398-1-ND	Digi-Key	$0.51	2
C18P, C19P, C21P, C25P, C26P	10uF Capacitor	100R15X106KV4E	709-1228-1-ND	Digi-Key	$0.75	5
C15P	1000pF Capacitor	08055A102GAT2A	478-3760-1-ND	Digi-Key	$0.61	1
C12P, C13P	33pF Capacitor	CBR08C330J1GAC	80-CBR08C330J1GAC	Mouser	$0.52	2
L1P, L2P	FERRITE BEAD 120 OHM 0603 1LN	MMZ1608B121CTAH0	445-2164-1-ND	Digi-Key	$0.10	2
L3P, L4P	560nH Inductor	PE-0805CM561JTT	553-1047-1-ND	Digi-Key	$0.42	2
						Total Price
						$44.34

Software Development



Software Development



Software Development

Overall structure flow ...

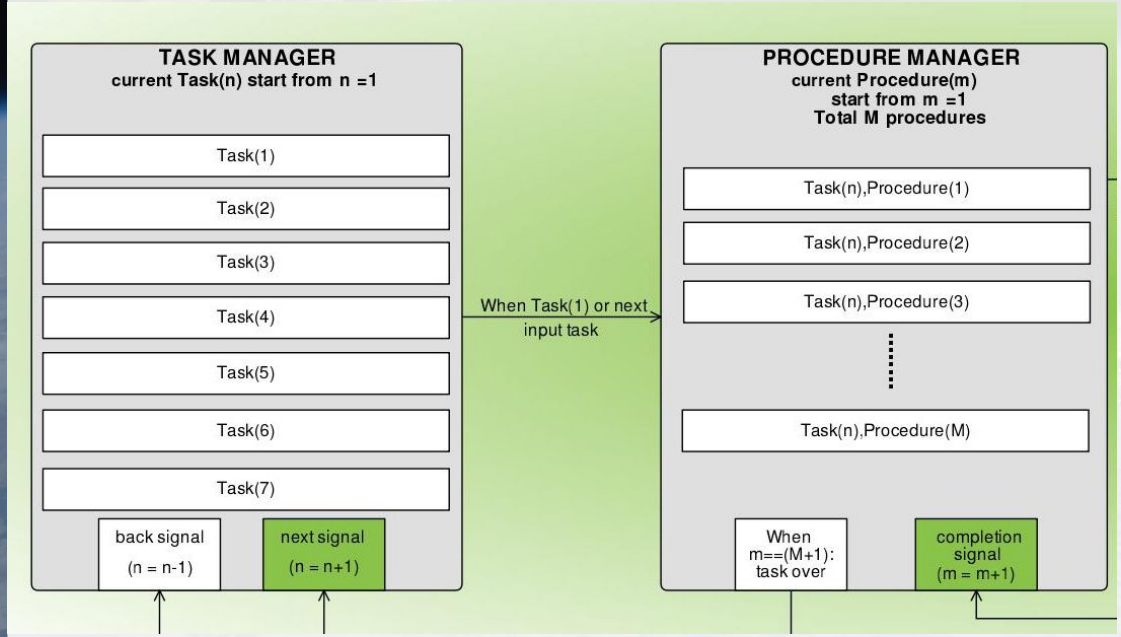


Figure. Task Controller

Task Controller

Two main part:

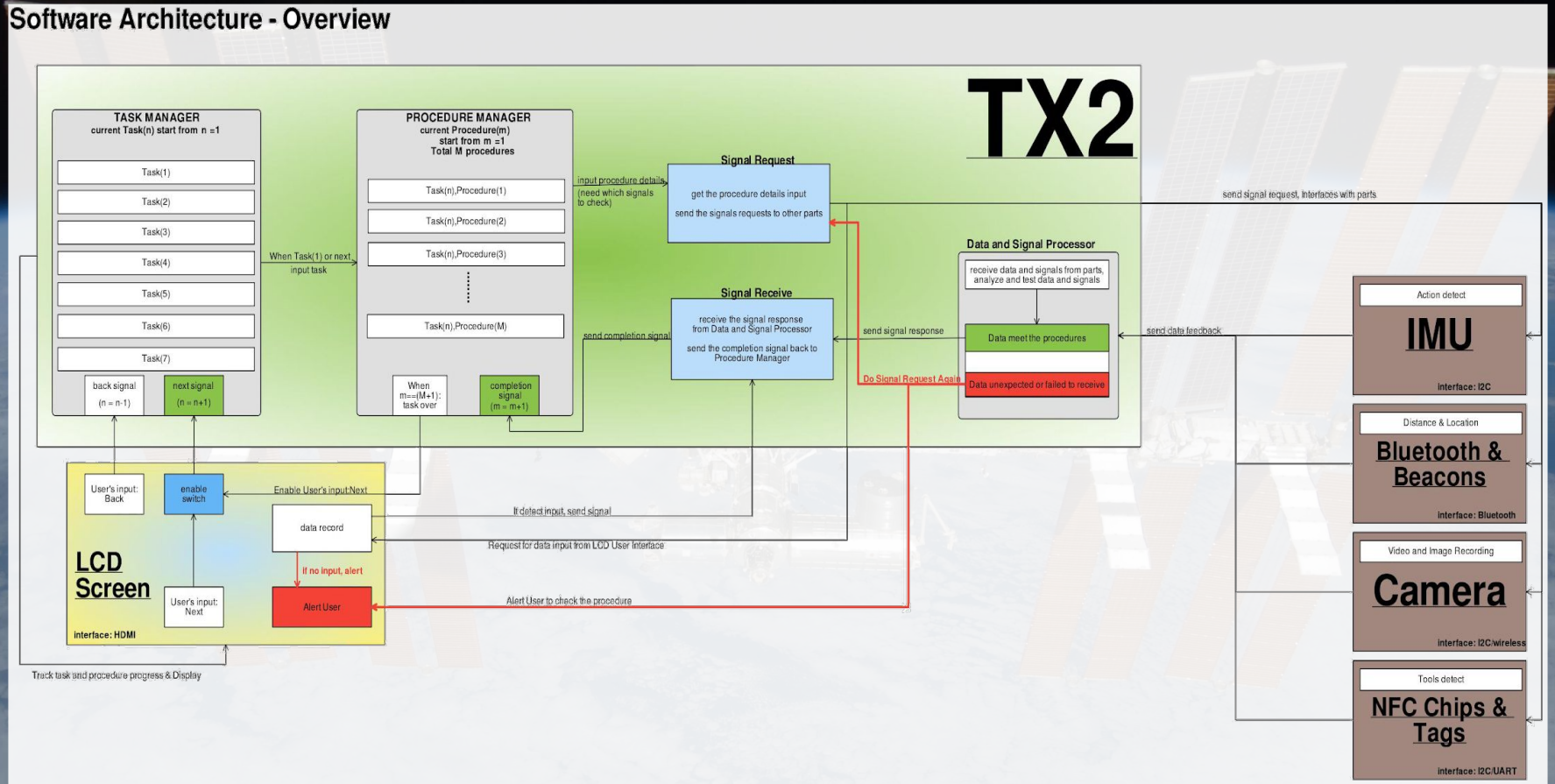
- **Task Manager:**
  Controlling the overall tasking flowing.
- **Procedure Manager:**
  Controlling the little procedures in each task.

When Task Manager switch to a new task, Procedure Manager activated;

Then Procedure Manager will send information to the **signal processing part**; (next slide)

When all procedures in Procedure Manager finished, user can go to the next task.

Software Development



Software Development

Overall structure flow (continued) ...

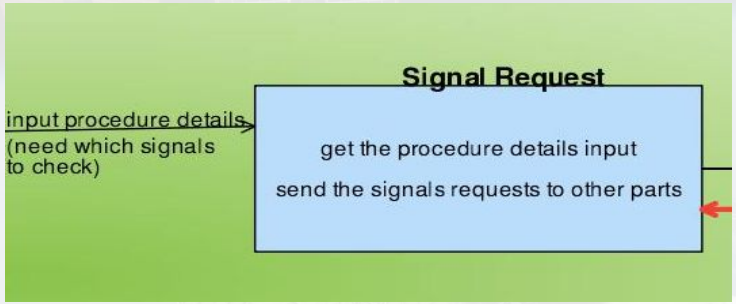


Figure. Signal Request

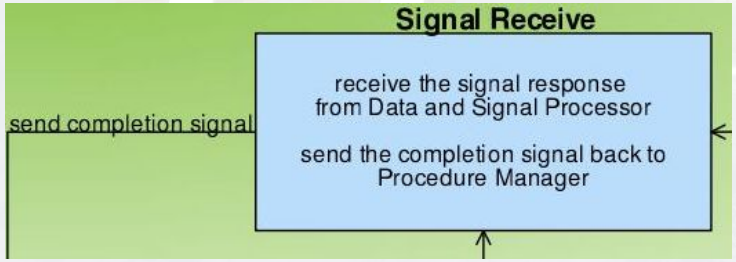


Figure. Signal Receive

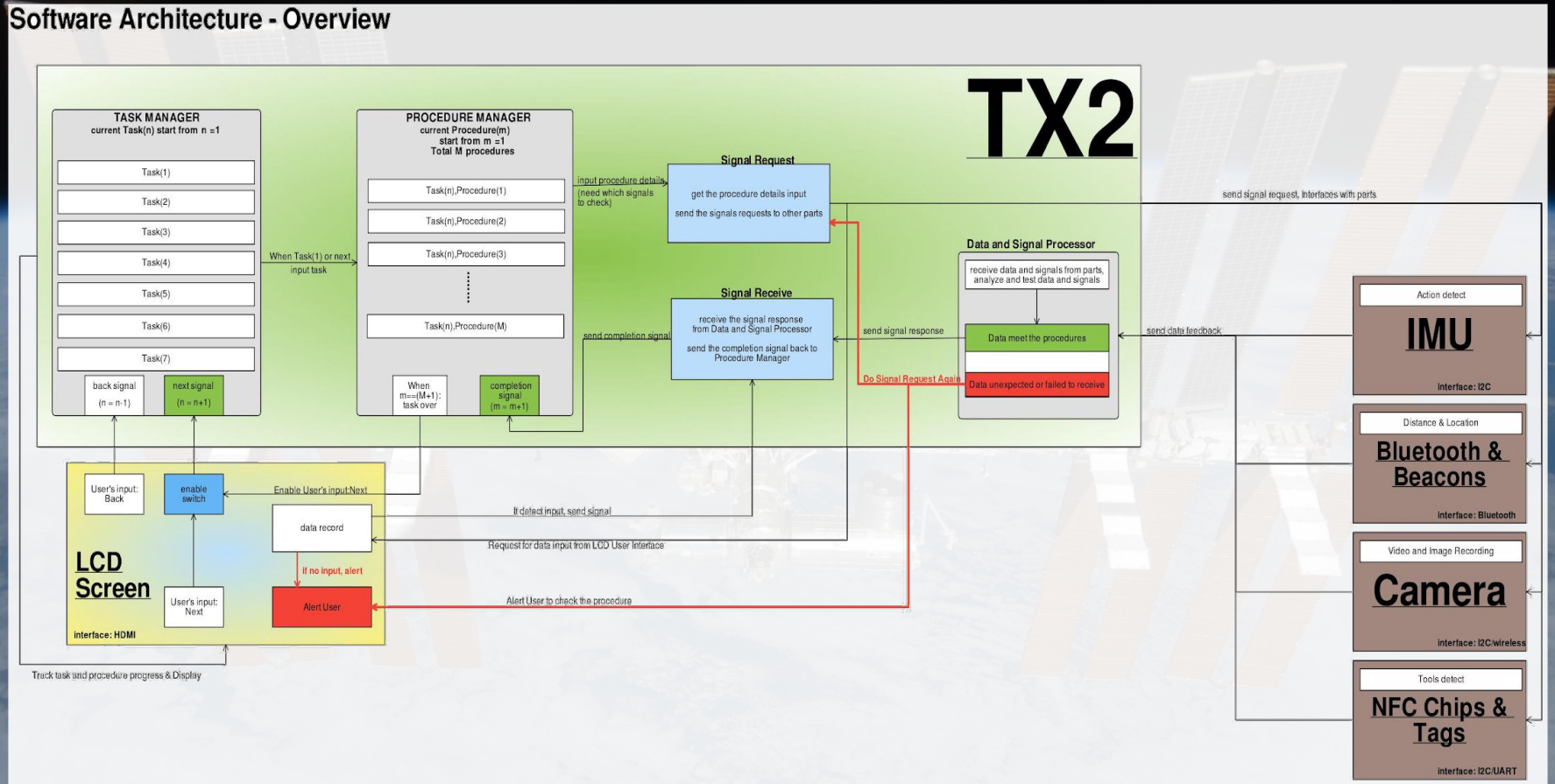
Signal Request and Receive Module

In Signal and Data Processing part, two modules used to process signal:

- **Signal Request**
  Receiving information from Procedure Manager, (which signals needed to check ...)
  Then sending the signal request to the parts (IMU, Bluetooth, NFC, Camera)

- **Signal Receive**
  Receiving the processed signal response from **Data and Signal Processor** (next slide)
  Then sending a completion signal to Procedure Manager, indicating the procedure completed

Software Development



Software Development

Overall structure flow (continued) ...

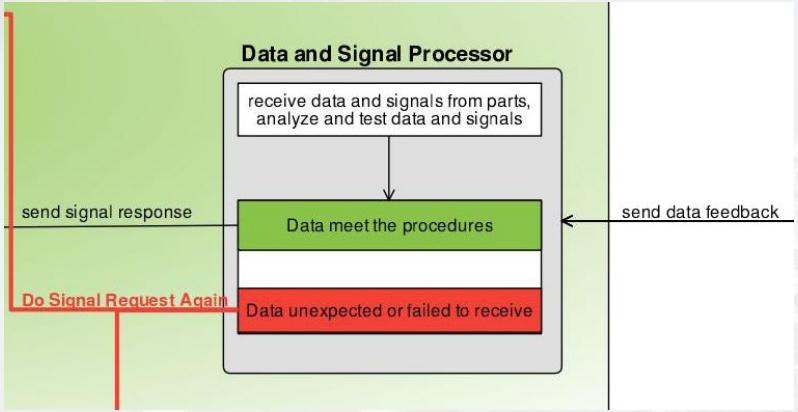


Figure. Data and Signal Processor

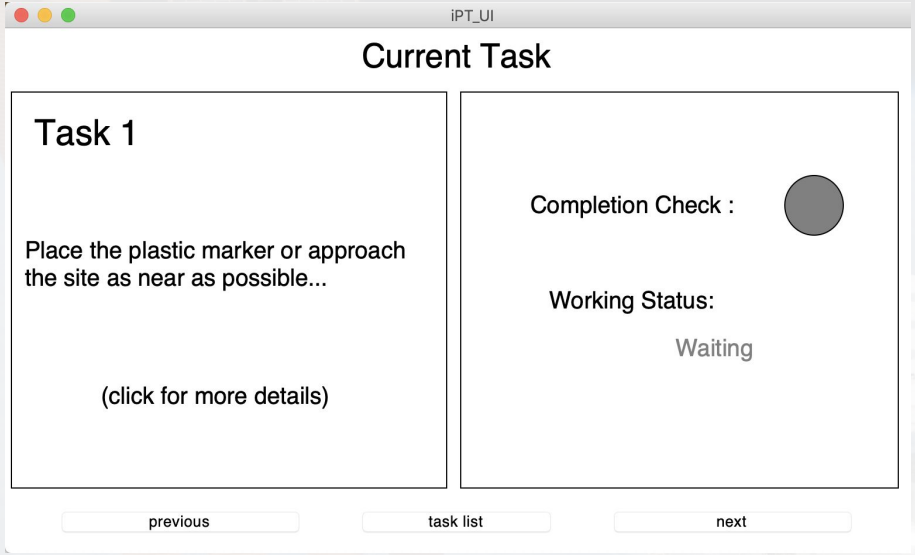
Data and Signal Processor

Core Module in Data and Signal Processing part:

Including all the algorithms used to process the signal and data coming from PARTS: (such as Video Processing)

- When the processor received data feedback from the PARTS, it would analyze this data and decide whether they satisfied the procedure's request or not.
- If satisfied, it would send the signal response to Signal Receive Module;
- If not, it would send a signal request to Signal Request Module and do this procedure again; at the same time, it will alert users on LCD Screen.

UI Overview

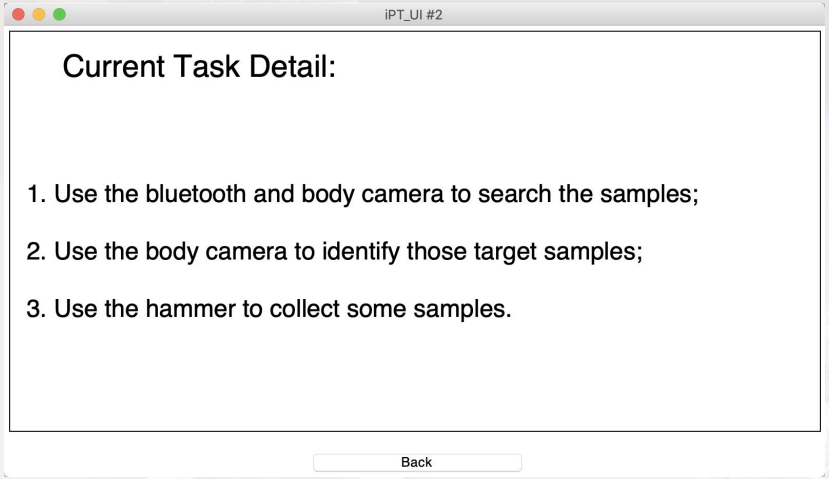


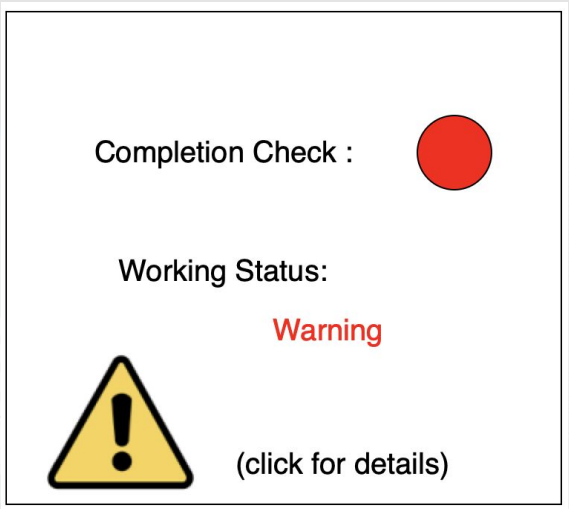
Green -- “Done” Gray -- “Waiting”

Yellow -- “In-progress” Red -- “Warning”

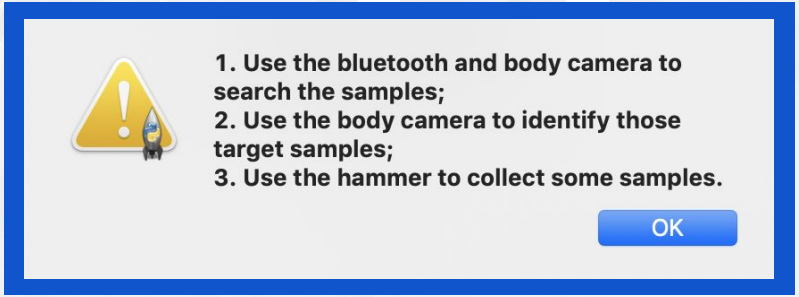
- Synopsis of current task.
- Status of current task, using different color to indicate each kind of state.
- Three buttons at bottom to help user switch tasks.
- Hint of details.

UI Detail Windows

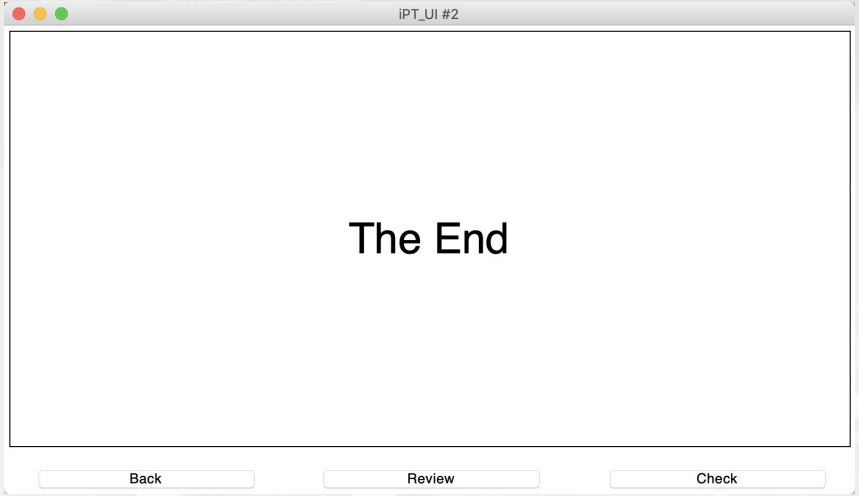


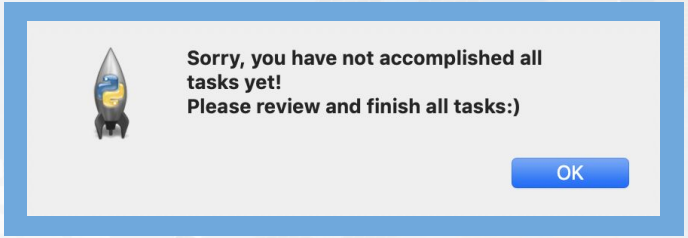


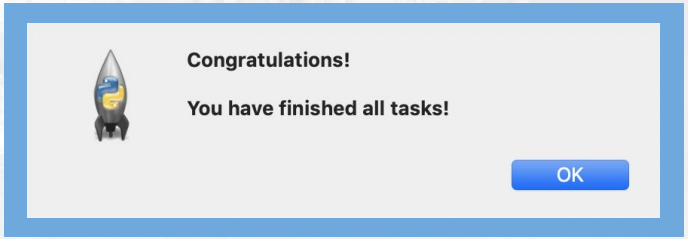
- Click left part of main interface to show the task detail.
- Click right part of main interface when working status is “Warning” to show the detail fo



UI overview







- Press “Back” to the last task.
- Press “Review” to task list window.
- Press “Check” to end the whole procedure.

UI demo


LOVE
HOPE
Christmas
laughter
Holidays
GIVING
Merry Christmas
Holidays

Acknowledgements

Thank you to:

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Brandon Pon

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Dr. Richard Joyce (NASA)

Laritech

for all of your assistance with the project.