AI & SUSTAINABILITY IN VET EDUCATION

Name of the Author/s: Sucessos Criativos, Lda | P. Porto

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Activity Reference: Developing the AISAVES KIT

Logo:

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JUSTIFICATION FOR THE AI-VET KIT COMPONENTS AND DESIGN CHOICES

The AI-VET Kit has been carefully designed to facilitate a wide range of projects related to artificial intelligence (AI), robotics, the Internet of Things (IoT), and computer vision. Each component included in the kit has been selected to provide the flexibility, scalability, and functionality required for both beginners and advanced users. This section outlines the rationale behind the selection of the hardware components, communication interfaces, and power management solutions, with an emphasis on the educational and practical needs of users.

1. MICROCONTROLLER AND DEVELOPMENT BOARD SELECTION

The **Raspberry Pi 5** and **ESP32-S3-WROOM-1-N8R8 Module** were selected as the central computing units in the AI-VET Kit for several reasons:

1. **Versatility and Performance:**

The Raspberry Pi 5 offers significant processing power with its quad-core Cortex-A76 processor, making it suitable for tasks such as computer vision, AI model execution, and multi-threaded operations. It comes in two configurations (4GB and 8GB of RAM), providing flexibility based on the performance requirements of various projects.

The ESP32 module, with its dual-core processor and integrated Wi-Fi and Bluetooth, is well-suited for IoT projects. It allows for low-power operations and can handle wireless communication tasks efficiently. Its ability to operate as a microcontroller with real-time capabilities complements the more powerful Raspberry Pi, which functions as the central hub in many project scenarios.

2. **Educational Value:**

The Raspberry Pi is renowned for its role in education, providing a full-fledged Linux-based environment that allows users to explore programming, hardware interfacing, and system administration. The Raspberry Pi's extensive documentation and community support make it ideal for educational purposes.

The ESP32 provides learners with exposure to microcontroller programming, real-time operations, and wireless communication protocols, offering a well-rounded learning experience in embedded systems.

3. **Broad Peripheral Support:**

Both the Raspberry Pi and ESP32 support a wide array of peripheral devices, including sensors, actuators, and displays, via their GPIO (General Purpose

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Input/Output) interfaces. The Raspberry Pi's 40-pin GPIO header and the ESP32's multiple GPIO pins allow for flexible hardware interfacing, enabling users to build a variety of projects from simple LED control to complex AI-driven robotic systems.

2. SENSOR AND ACTUATOR SELECTION

The sensors and actuators included in the AI-VET Kit are essential for building interactive systems and smart devices. These components provide critical input/output functionality that allows the AI-VET Kit to be used in a broad range of applications, from robotics to environmental monitoring.

1. **DHT11 Temperature-Humidity Sensor:**
    - The DHT11 was chosen for its reliability and ease of use in environmental monitoring projects. It provides accurate temperature and humidity readings, making it an ideal sensor for IoT applications where data collection and remote monitoring are required.
2. **HC-SR04P Ultrasonic Sensor:**
    - This sensor is an industry-standard solution for distance measurement, commonly used in robotics for obstacle avoidance. Its simple operation and compatibility with both the Raspberry Pi and ESP32 make it an excellent choice for autonomous vehicle projects or object detection systems.
3. **LDR Sensor Module with Potentiometer:**
    - The LDR (Light Dependent Resistor) sensor module is ideal for detecting changes in light levels, a crucial feature in projects that involve smart lighting, security systems, or environment-based automation. The inclusion of an adjustable potentiometer allows for calibration, making it adaptable to different lighting conditions.
4. **Microservo SG90:**
    - Servos are commonly used in robotics to control movement, particularly for steering or manipulating objects. The Microservo SG90 offers 180-degree movement and sufficient torque for lightweight applications, making it an excellent choice for robotic arms, vehicle steering mechanisms, or automated systems that require precise motion control.

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5. **Dual H-Bridge Motor Driver (L298N):**

    - The L298N motor driver allows for the control of up to two bidirectional DC motors, which is essential in robotics for driving wheels or other mechanical components. Its ability to handle high-current motors and support external power sources makes it suitable for larger-scale robotics projects that require more power than what microcontroller GPIO pins can supply directly.

3. DISPLAY AND OUTPUT DEVICES

Displays play a critical role in human-machine interaction, providing real-time feedback or data visualization. The AI-VET Kit includes a versatile OLED display for this purpose.

1. **0.95-inch OLED Display (SSD1306):**

    - This display was selected for its compact size and I2C communication interface, making it easy to integrate into projects with minimal wiring. OLED displays are highly efficient, providing sharp, high-contrast visuals with low power consumption. The SSD1306 is widely supported by libraries across multiple platforms, making it easy for users to display text, graphics, or sensor data in their projects.

2. **WS2812 RGB Programmable LED Strip:**

    - The WS2812 LED strip adds an element of visual feedback to projects, allowing users to program complex lighting effects. The individually addressable LEDs can be controlled to display a wide range of colors and patterns, making them ideal for visualizing sensor data or creating aesthetically pleasing light displays.

4. COMMUNICATION INTERFACES

The ability to communicate with external devices, sensors, and other microcontrollers is crucial for IoT and AI applications. The communication interfaces in the AI-VET Kit ensure that users can connect and control a wide range of peripherals.

1. **I2C (Inter-Integrated Circuit):**

    - I2C is a two-wire communication protocol commonly used for connecting sensors, displays, and other low-speed peripherals. The inclusion of I2C-compatible devices such as the OLED display and various sensors allows users to expand their projects with minimal

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wiring. I2C is also supported on both the Raspberry Pi and ESP32, ensuring seamless integration between different components.

2. **SPI (Serial Peripheral Interface):**
    - SPI is a faster communication protocol compared to I2C and is used for devices requiring higher data transfer rates, such as flash memory and some sensors. Its inclusion allows for flexibility in high-speed data transfers between the Raspberry Pi or ESP32 and other peripherals.
3. **Wi-Fi and Bluetooth:**
    - The ESP32's built-in Wi-Fi and Bluetooth capabilities make it ideal for IoT projects where wireless communication is necessary. The Raspberry Pi's support for Wi-Fi (including both 2.4GHz and 5GHz bands) and Bluetooth 5.0 provides high-speed internet connectivity and device pairing options. This combination allows the AI-VET Kit to function as a hub for cloud-based data storage, remote control, and communication with other devices in a smart environment.

5. POWER MANAGEMENT

Effective power management is essential for ensuring the reliability and longevity of embedded systems and IoT devices. The AI-VET Kit includes robust power options to support both the microcontrollers and external devices.

1. **Battery Holder (for 4 AA Batteries):**
    - The battery holder provides a portable power solution for projects that require mobility, such as robotics or outdoor monitoring systems. It is designed to supply 6V to motors and other peripherals, ensuring consistent performance in situations where access to mains power is not feasible.
2. **27W USB Type-C Power Supply for Raspberry Pi:**
    - The 27W power supply is specifically chosen to meet the high power demands of the Raspberry Pi 5, particularly when peripherals such as cameras or motors are connected. It ensures stable operation even under full load, preventing power-related system crashes or slowdowns.

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6. MECHANICAL COMPONENTS AND CHASSIS

The mechanical components included in the AI-VET Kit, such as the chassis and wheels, provide the foundation for building mobile robotic systems.

1. **2WD Chassis for Robot Car:**
    - The two-wheel-drive (2WD) chassis is the base structure for building a robot car. It is made from durable acrylic, which is both lightweight and sturdy enough to support the components mounted on it. The chassis is pre-drilled for mounting motors, wheels, and other components, reducing the complexity of assembly.
2. **TT Motors and Rubber Wheels:**
    - The TT motors and rubber wheels are specifically chosen for their compatibility with the 2WD chassis and the L298N motor driver. They offer sufficient torque and traction for a wide range of surfaces, making them suitable for indoor or outdoor robotic projects.

7. Educational and Practical Benefits

The components in the AI-VET Kit were selected not only for their technical capabilities but also for their educational value. The inclusion of microcontrollers, sensors, actuators, and displays allows users to explore concepts such as:

- **Artificial Intelligence:** Using the Raspberry Pi's processing power and camera modules, users can implement computer vision systems and machine learning models.
- **Robotics:** The motor drivers, servos, and chassis provide all the necessary components to build autonomous or remote-controlled robots.
- **IoT:** With the ESP32's wireless communication features, users can create smart devices that communicate over the internet, collect data, and interact with cloud services.

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TECHNICAL SPECIFICATIONS

1. OVERVIEW

The AI-VET Kit is designed to enable AI-driven projects, computer vision, robotics, and IoT. It includes a wide range of components, such as development boards, sensors, actuators, cameras, and more, to help users build intelligent systems. This section outlines the technical characteristics for the kit components.

2. HARDWARE COMPONENTS

2.1 MICROCONTROLLER AND DEVELOPMENT BOARD

- **Raspberry Pi 5 (4GB/8GB)**
  - CPU: Quad-core Cortex-A76 (ARM v8) 64-bit SoC @ 2.4GHz
  - Memory: 4GB/8GB LPDDR4-3200 SDRAM
  - USB Ports: 2 x USB 3.0, 2 x USB 2.0
  - Networking: Gigabit Ethernet, 802.11ac wireless, Bluetooth 5.0
  - GPIO: 40-pin header, including UART, SPI, I2C, and GPIO interfaces
  - Storage: microSD card slot supporting up to 128GB
- **ESP32-S3-WROOM-1-N8R8 Module**
  - CPU: Dual-core 32-bit Xtensa LX7 @ 240 MHz
  - RAM: 512 KB SRAM
  - Connectivity: Wi-Fi 802.11b/g/n, Bluetooth 5.0 LE
  - GPIO: 34 GPIOs, supporting I2C, SPI, UART, PWM, and ADC

2.2 CAMERAS

- **Raspberry Pi Camera Module V3**
  - Resolution: 12MP
  - Field of view: 120°
  - Interface: CSI (Camera Serial Interface)
  - Supports 1080p video recording at 30fps
- **Raspberry Pi Camera Board V2**
  - Resolution: 8MP
  - Supports 1080p video recording at 30fps
  - Interface: CSI (Camera Serial Interface)

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- **Camera Accessories**
  - **Official FPC Camera Cable**: 200mm flat cable to connect the camera module to the Raspberry Pi
  - **Micro HDMI to HDMI Cable**: 1m cable for video output from Raspberry Pi to monitor or display

2.3 SENSORS

- **DHT11 Temperature-Humidity Sensor**
  - Operating voltage: 3.3V to 5V
  - Temperature range: 0–50°C, accuracy ±2°C
  - Humidity range: 20%–90%, accuracy ±5%
- **HC-SR04P Ultrasonic Sensor**
  - Operating voltage: 3.3V to 5V
  - Sensing distance: 2cm – 400cm
  - Accuracy: ±3mm
- **LDR Sensor Module with Potentiometer**
  - Operating voltage: 3.3V to 5V
  - Detects changes in light levels using a Light Dependent Resistor (LDR)

2.4 ACTUATORS

- **Microservo SG90**
  - Torque: 1.6Kg/cm @ 4.8V
  - Operating voltage: 4.8V
  - Operating angle: 180 degrees
- **Dual H-Bridge Motor Driver (L298N)**
  - Operating voltage: 5V – 35V
  - Drive current: 2A max per channel
  - Controls up to 2 bidirectional DC motors or 1 stepper motor

2.5 DISPLAY

- **0.95-inch OLED Display (SSD1306)**
  - Resolution: 128x64 pixels
  - Interface: I2C
  - Operating voltage: 3.3V to 5V

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2.6 OTHER ELECTRONICS

- **WS2812 RGB Programmable LED Strip**
  - LED count: 15
  - Operating voltage: 5V
  - Data protocol: Single-wire control, supports daisy-chaining
- **Tactile Button Switch Kit**
  - Type: Normally open (NO)
  - Operating voltage: 3.3V to 5V
- **Breadboards**
  - Tie points: 400-point (solderless)

2.7 POWER SUPPLY

- **Battery Holder (for 4 AA Batteries)**
  - Output voltage: 6V (when using 1.5V AA batteries)
- **27W USB Type-C Power Supply for Raspberry Pi 5**
  - Input: 100-240V AC
  - Output: 5V DC, 5.4A

3. CONNECTIVITY AND COMMUNICATION INTERFACES

3.1 Wireless Communication

- **Wi-Fi** (Raspberry Pi and ESP32 modules)
  - Standards: IEEE 802.11b/g/n/ac
  - Frequency: 2.4GHz for ESP32, 2.4GHz and 5GHz for Raspberry Pi
- **Bluetooth** (Raspberry Pi and ESP32 modules)
  - Bluetooth version: 5.0 LE (Low Energy)

3.2 Wired Communication

- **GPIO Header**
  - Number of Pins: 40
  - Pinout: General-purpose input/output, UART, I2C, SPI, PWM

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- **I2C Communication**
    - Used for communication with sensors and displays such as the SSD1306 OLED.
- **SPI Communication**
    - Supported for high-speed peripherals like displays and flash memory.

4. MECHANICAL COMPONENTS

4.1 Chassis

- **2WD Chassis for Robot Car**
    - Material: Acrylic
    - Dimensions: Fits standard TT motors and caster wheels

4.2 Motors and Wheels

- **TT Motors (2x)**
    - Voltage: 3V to 6V
    - No-load speed: 200 RPM @ 6V
- **Rubber Wheels (2x)**
    - Diameter: 65mm
    - Compatible with TT motors
- **Caster Wheel (1x)**
    - Free-rolling, omnidirectional wheel for balancing robot chassis

5. ASSEMBLY HARDWARE

- **Acrylic TT Motor Holders (4x)**
    - Custom-fit for mounting TT motors to the chassis
- **Screws and Nuts**
    - Screw sizes: 3mm x 30mm, 3mm x 8mm
    - Nuts: 3mm standard hex
- **Copper Cylinder Spacers**
    - Size: Compatible with 3mm screws

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6. POWER MANAGEMENT

The AI-VET Kit includes multiple power sources to support different components and configurations. The Raspberry Pi and ESP32 modules have dedicated power supplies and voltage regulators, while external power sources such as batteries are used for motors and other peripherals.

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