INVENTORS:

Patent Title:
“Solar Self-Charging Smart Backpack”

Patent Idea:

A backpack equipped with a foldable solar panel and built-in battery that harnesses sunlight to charge phones and laptops while traveling.

TEAM MEMBERS:

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ABSTRACT

The present invention discloses a **solar-powered**, **self-charging smart backpack** designed to autonomously generate and store electrical energy from sunlight to charge portable electronic devices such as **smartphones**, **tablets**, **laptops**, **wearables**, and **IoT devices**. The system integrates a foldable photovoltaic (PV) panel, an onboard rechargeable battery pack, and a microcontroller-based power management unit, providing uninterrupted energy harvesting during travel, commuting, trekking, and emergency conditions.

The invention incorporates a multi-layered backpack structure with embedded cabling, waterproof compartments, and intelligent circuitry enabling efficient MPPT-based solar conversion, battery protection, and multi-port output distribution. The system continuously monitors solar input, battery health, charging patterns, thermal limits, and device load using embedded sensors.

The invention ensures a portable, sustainable, and user-friendly energy-generation solution, minimizing dependence on grid electricity while enhancing outdoor usability and travel convenience. The integrated foldable solar panel, high-capacity battery, and adaptive charging electronics collectively enable reliable power delivery for a wide range of consumer electronics. The present invention therefore offers a versatile, eco-friendly, and smart wearable energy-harvesting device suitable for students, travelers, trekkers, professionals, and emergency-first responders.

FIELD OF THE INVENTION

The present invention relates to the field of portable energy-generation systems, wearable electronics, and solar harvesting technologies. More specifically, it pertains to the design and development of a solar-powered smart backpack equipped with foldable photovoltaic panels, intelligent energy-management circuitry, integrated battery storage, and multi-port charging interfaces.

The invention falls under the domain of renewable energy applications, sustainable consumer products, and portable charging solutions. It further relates to the integration of microcontroller-based MPPT, IoT-enabled power monitoring, and ergonomically engineered backpack architecture, forming a self-sustained, autonomous charging system for personal electronic devices.

This invention additionally pertains to improvements in travel gear, outdoor equipment, and emergency readiness products, offering enhanced functionality through the seamless combination of solar harvesting, smart electronics, and practical backpack utility.

BACKGROUND OF THE INVENTION

Portable electronic gadgets such as **smartphones**, **tablets**, **GPS devices**, **wireless earphones**, **power banks**, and **laptops** have become essential components of everyday life. However, the usability of such devices is inherently limited by battery capacity, often requiring frequent recharging from grid-powered outlets. This poses a challenge for students, travelers, hikers, remote workers, and individuals engaged in long outdoor activities where access to power sources is limited.

Power banks, despite being widely used, require prior charging and lose efficiency over time. Traditional solar chargers exist, but they are typically rigid, bulky, or separate accessories, making them inconvenient to carry during daily travel. Many such devices lack energy storage, smart regulation, or durability suitable for outdoor conditions.

Existing backpack designs with integrated solar panels suffer from several limitations:

1. Rigid panels limit flexibility and portability.
2. Lack of MPPT-based power optimization, resulting in poor charging efficiency.
3. Basic circuits without intelligent power distribution for multiple devices.
4. Insufficient battery safety features (overload, overheating).
5. Poor integration of cables and ports leading to user discomfort.
6. No IoT or smart-monitoring features.

These gaps highlight the need for an advanced backpack capable of independently generating, managing, and delivering power in a safe, efficient, and user-friendly manner.

In developing regions and remote travel environments, electrical access is unpredictable. Students traveling long distances, field-workers in agriculture or surveying, wildlife researchers, trekkers, and rural commuters frequently face phone battery exhaustion, restricting communication and safety.

Furthermore, during long journeys or emergency conditions such as natural disasters, the absence of electricity can limit critical communication and navigation capabilities. A self-sustained charging system embedded into an

everyday object such as a backpack can significantly reduce dependency on external chargers.

Previous attempts at solar-powered backpacks have not adequately integrated:

- **Flexibility and foldability** of solar panels
- **High-efficiency energy conversion** using MPPT
- **Smart battery management systems (BMS)**
- **Thermal and short-circuit safeguards**
- **Universal output (USB-A, USB-C PD, DC laptop port)**
- **Wireless charging**
- **Ergonomics and lightweight design**
- **Mobile app monitoring**
- **Waterproof and shockproof compartments**

Therefore, a need exists for a **technically robust, safe, and efficient solar smart backpack**.

Key problems with current energy-access solutions include:

- **Unreliable sunlight conversion** due to lack of MPPT
- **Battery degradation** due to poor charging logic
- **Limited device compatibility**
- Lack of **port protection**
- No **energy analytics**
- No **expandable solar surface area**
- Heavyweight and unsustainable design

Hence, the proposed invention introduces:

- An **advanced PV-based charging system**
- Smart electronics integrated into a **wearable platform**
- Robust output systems for universal compatibility
- User safety and device protection

- A durable, eco-friendly, and portable energy solution

This invention addresses all the above limitations while improving user convenience, functionality, and safety.

The primary and subsidiary objectives of the present invention are as follows:

1. To design and develop a **self-charging solar backpack** capable of autonomously harvesting solar energy during outdoor movement or static exposure.
2. To integrate **foldable or flexible photovoltaic panels** capable of providing maximum exposure and efficient energy generation.
3. To include a **high-capacity rechargeable battery pack** for storing solar-generated energy for later use.
4. To implement a **microcontroller-controlled MPPT (Maximum Power Point Tracking)** system for optimal solar conversion.
5. To provide **multiple power output interfaces**, including USB-A, USB-C PD, and DC laptop charging.
6. To incorporate a **wireless charging pad** for convenience.
7. To embed a **comprehensive Battery Management System (BMS)** ensuring protection against overcharging, overcurrent, overheating, and short circuits.
8. To facilitate **IoT or Bluetooth app connectivity** for real-time monitoring of charging status, solar input, and usage analytics.
9. To provide a **waterproof, shock-resistant backpack design** suitable for travel, trekking, and emergency conditions.
10. To reduce dependency on electricity and promote **sustainable, renewable energy usage**.
11. To enhance safety and reliability by integrating **thermal sensors and protective circuitry**.
12. To offer a lightweight, ergonomic, and durable product with **integrated cable-routing channels**.
13. To support **universal device compatibility** with intelligent load detection.

SUMMARY OF THE INVENTION

The present invention provides a **solar-powered, intelligent, self-charging backpack** that integrates renewable energy harvesting, high-efficiency power management, and multi-device charging capabilities into a single, ergonomic wearable product. The invention combines **foldable photovoltaic panels**, a **smart microcontroller-based MPPT system**, an **embedded rechargeable battery pack**, and a **multi-port charging interface**, enabling continuous and autonomous charging of electronic devices during travel or outdoor activity.

The invention is designed to overcome the limitations of existing solar chargers, power banks, and conventional backpack-based charging products by providing a **proactive, efficient, durable, and user-safe power solution** suitable for students, travelers, trekkers, professionals, emergency personnel, and individuals in power-deficient environments.

The system is broadly divided into three coordinated functional modules:
(a) Solar Energy Harvesting Module,
(b) Power Management and Battery Storage Module, and
(c) User Interface and Device Charging Module.
These modules work cohesively through a central microcontroller that manages energy flow, regulates power delivery, ensures safety, logs performance, and optionally communicates with a mobile application.

(a) Solar Energy Harvesting Module

The first component of the system is the **flexible or foldable photovoltaic solar panel assembly**, mounted externally on the backpack surface. The solar panel is designed to maximize exposure to sunlight while maintaining a lightweight and aesthetic profile. The foldable structure allows the user to expand the effective surface area when required and fold it back into a compact form while commuting.

The PV assembly is laminated with a waterproof and UV-resistant coating. The panels generate DC power in the range of 5V–20V depending on sunlight intensity. This module ensures **continuous power generation during walking, travel, trekking, or static sun exposure**.

(b) Power Management and Battery Storage Module

The second component is the **microcontroller-driven MPPT-based power management system**. The MPPT algorithm dynamically adjusts the panel's operating point to maximize solar energy conversion efficiency.

This module includes:

- A rechargeable **Li-ion/Li-Po battery pack** (10,000–30,000 mAh)
- A **buck-boost converter** for voltage regulation
- A **Battery Management System (BMS)** for overcharge, thermal, short-circuit, and overcurrent protection
- A **microcontroller unit** for monitoring solar input, battery status, and charging conditions
- Thermal sensors for real-time temperature measurement

The module intelligently switches between:

- Direct solar-to-device charging
- Solar-to-battery charging
- Battery-to-device output

This ensures optimal utilization of available solar energy and safe operation of the battery system.

(c) User Charging Interface and Connectivity Module

The third module provides the end-user charging interfaces including:

- **USB-A output ports** (5V/2A)
- **USB-C PD output port** for laptops (up to 20V, 45W/65W)
- **DC output** for devices like cameras or routers
- **Wireless charging pad (Qi standard)** with waterproof protection
- LED indicators for solar input, battery percentage, and output status

The backpack may optionally include:

- **Bluetooth or IoT connectivity**

- A mobile application showing:
    - Real-time solar input
    - Battery health
    - Charging analytics
    - Historical usage trends

The entire system is enclosed in a **waterproof, shockproof, heat-resistant backpack structure**, designed for comfort, durability, safety, and aesthetic appeal.

Novelty and Technical Advantage

The uniqueness of the present invention lies in the **synergistic combination** of:

- Foldable PV panels
- Smart MPPT controller
- High-safety BMS
- Universal multi-port output
- Wireless charging
- IoT monitoring
- Ergonomic backpack integration

Unlike conventional solar chargers or power banks, the invention offers a **self-contained, real-time, user-friendly wearable energy solution**, making portable charging reliable, sustainable, and efficient

DETAILED DESCRIPTION OF THE INVENTION

Overview:

The invention comprises the following key components:

1. Solar Panel Assembly
2. Rechargeable Battery Pack
3. Power Management Unit with MPPT
4. Microcontroller Unit
5. Output Interface Module
6. Wireless Charging Pad
7. Backpack Body Structure
8. Thermal and Safety Sensors
9. Optional IoT/Bluetooth Module
10. Cable Routing and Waterproof Housing

The backpack incorporates multiple layers for strength, waterproofing, and cable separation.

Ref. No.	Component	Function	Example / Suggested Specifications
1	Foldable Solar Panel Assembly	Harvests solar energy and supplies DC power	10W–30W flexible monocrystalline PV; foldable 2–4 panel structure; laminated waterproof coating
2	Rechargeable Battery Pack	Stores solar-generated energy for later use	Li-ion/Li-Po battery, 10,000–30,000 mAh; overcharge/thermal protection
3	MPPT Charge Controller	Maximizes solar absorption efficiency	Microcontroller-controlled MPPT; DC–DC conversion
4	Microcontroller Unit (MCU)	Controls power flow,	ESP32, ARM Cortex-M, or similar low-power MCU

		safety, and regulation	
5a	USB-A Output Module	Powers regular devices	5V/2A regulated output
5b	USB-C PD Output Module	Charges laptops via USB-C Power Delivery	20V up to 45W/65W output
5c	DC Output Port	Powers cameras, routers, etc.	12V DC barrel output
6	Wireless Charging Pad	Provides cable-free charging	Qi standard, 5W–15W
7	Backpack External Body	Physical casing protecting all components	Waterproof polyester/nylon, UV-resistant, anti-theft pockets
8	Thermal & Safety Sensors	Prevents overheating and unsafe operation	NTC thermistor, thermal cutoff switch
9	Bluetooth / IoT Module	Enables app connectivity	BLE 5.0 / Wi-Fi module

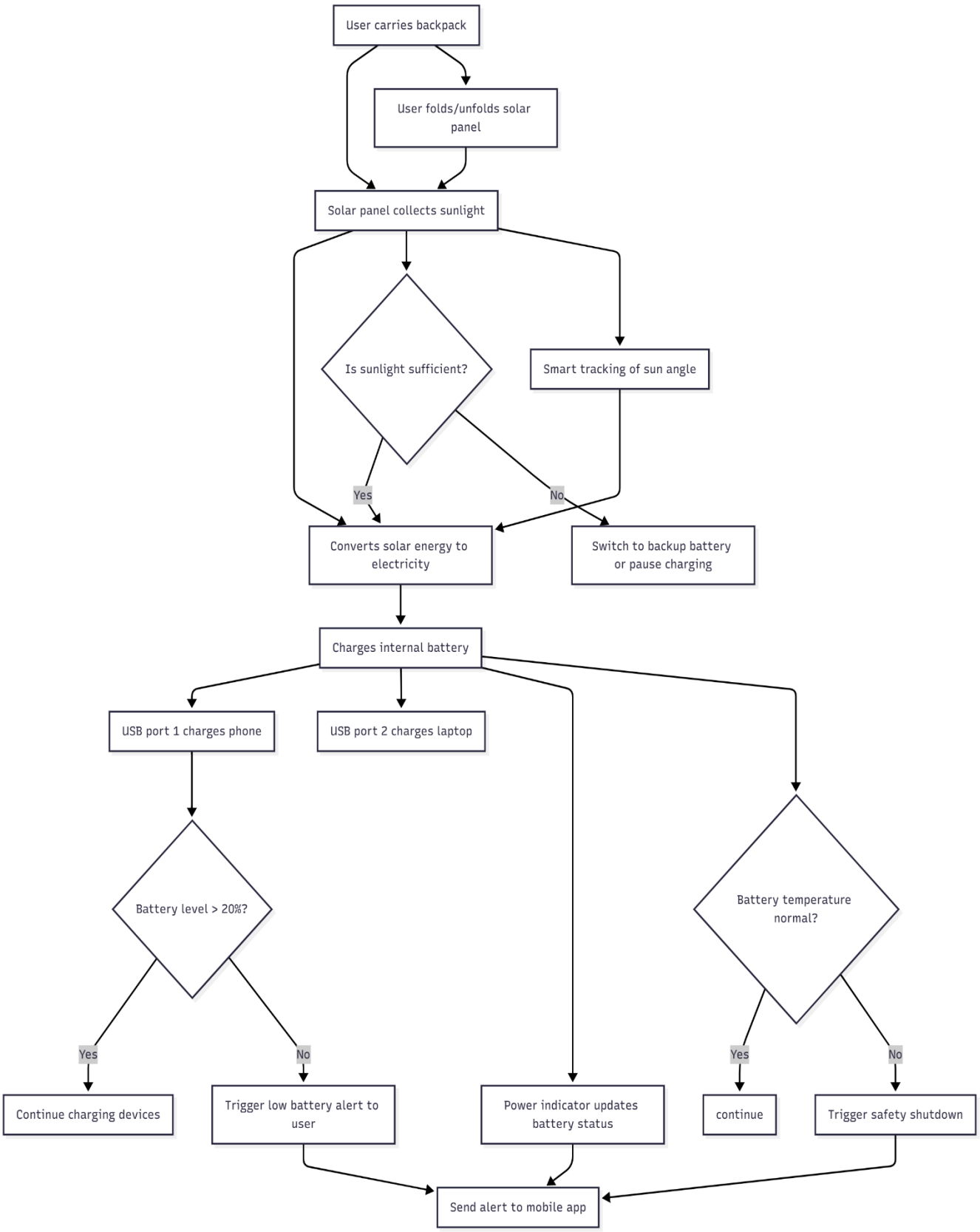
ADVANTAGES OF THE INVENTION

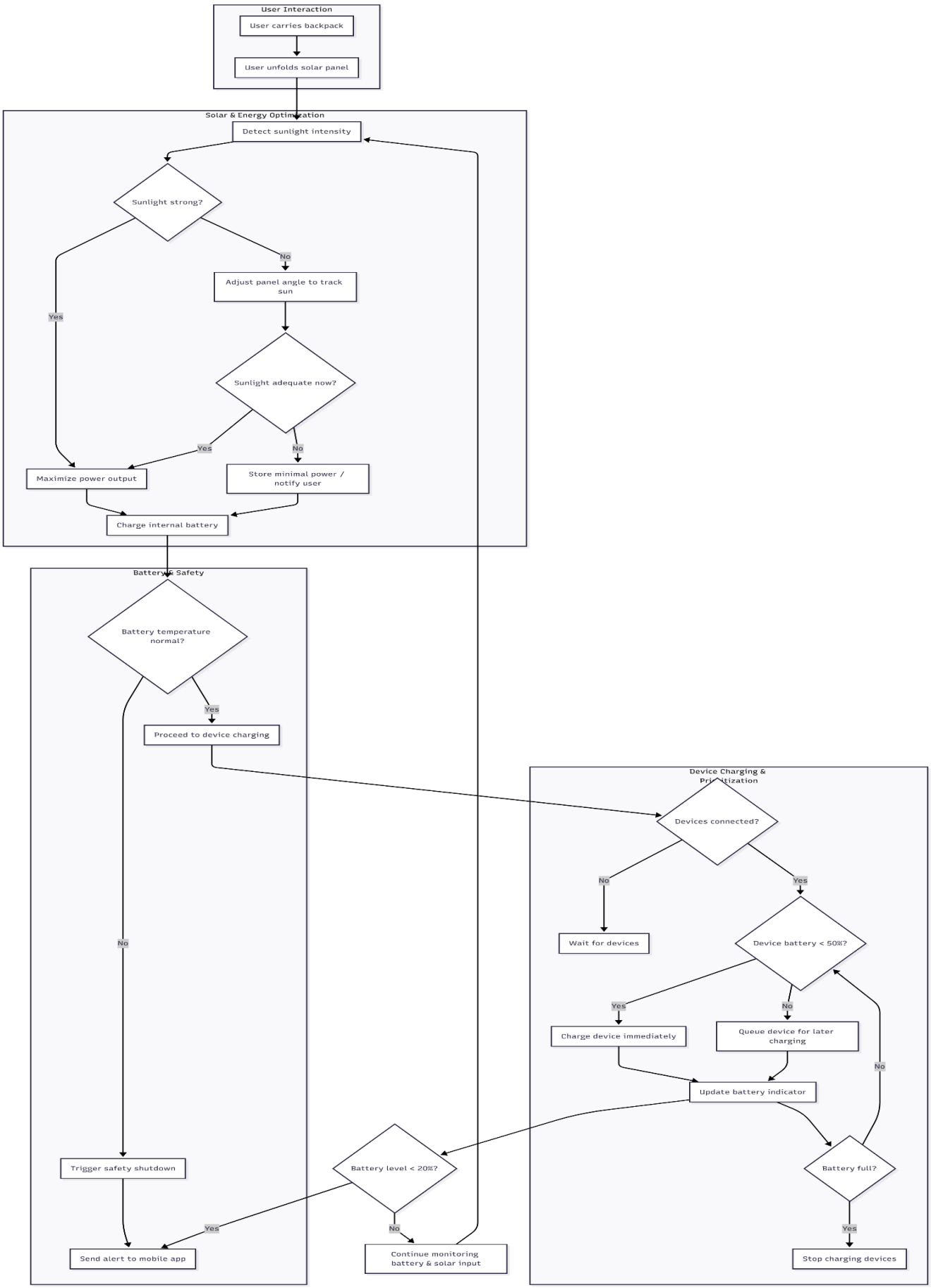
1. Provides continuous, eco-friendly charging.
2. Reduces need for external chargers.
3. Smart MPPT increases charging efficiency.
4. Multi-device compatibility.
5. Enhanced durability and waterproof structure.
6. High safety due to intelligent BMS.
7. Foldable panels increase solar exposure.
8. Wireless charging for user convenience.
9. Ideal for emergencies, travel, trekking.
10. Minimizes carbon footprint.

APPLICATIONS OF THE INVENTION

- Students and office commuters
- Trekking and hiking
- Remote field workers
- Disaster and emergency response
- Military and outdoor operations
- Camping and adventure travel
- Rural regions with limited grid access
- Smart travel accessories
- IoT-powered wearable systems

DIAGRAMS:


User carries backpack
User folds/unfolds solar panel
Solar panel collects sunlight
Is sunlight sufficient?
Smart tracking of sun angle
Yes
No
Converts solar energy to electricity
Switch to backup battery or pause charging
Charges internal battery
USB port 1 charges phone
USB port 2 charges laptop
Battery level > 20%?
Battery temperature normal?
Yes
No
Yes
No
Continue charging devices
Trigger low battery alert to user
Power indicator updates battery status
continue
Trigger safety shutdown
Send alert to mobile app


User Interaction
User carries backpack
User unfolds solar panel
Solar & Energy Optimization
Detect sunlight intensity
Sunlight strong?
Yes
No
Adjust panel angle to track sun
Sunlight adequate now?
Yes
No
Maximize power output
Store minimal power / notify user
Charge internal battery
Battery & Safety
Battery temperature normal?
Yes
No
Proceed to device charging
Trigger safety shutdown
Send alert to mobile app
Device Charging & Prioritization
Devices connected?
No
Yes
Wait for devices
Device battery < 50%?
Yes
No
Charge device immediately
Queue device for later charging
Update battery indicator
Battery full?
No
Yes
Stop charging devices
Battery level < 20%?
Yes
No
Continue monitoring battery & solar input

CLAIMS:

1. A solar-powered smart backpack comprising foldable solar panels, an integrated battery, and a microcontroller-driven power management system.
2. The backpack of claim 1 wherein the solar panels are flexible and foldable to increase energy capture.
3. The backpack of claim 1 wherein the power management employs MPPT for optimal conversion.
4. The backpack of claim 1 wherein the battery includes overcharge, overcurrent, and thermal protection circuits.
5. The backpack of claim 1 comprising USB-A, USB-C PD, wireless charging, and DC output ports.
6. The backpack of any preceding claims wherein the microcontroller regulates power distribution between solar, battery, and output.
7. The backpack includes thermal sensors, voltage sensors, and current sensors.
8. The backpack optionally includes Bluetooth or IoT connectivity for monitoring.
9. The invention provides a portable, eco-friendly energy generator integrated into a wearable travel accessory.

DATE & SIGNATURE PAGE:

Date: ___ / ___ / 2025

Inventors:

1._____

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Signatures:

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