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# Review on IV drip monitoring with a wearable hydration sensor for pregnant women

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***Abstract:*** Intravenous (IV) infusion is the predominant therapy used for hospitalized patients. Observing the flow rate of the fluid is vital for patient safety, Over -infusion and under-infusion lead to serious health issues. There are different methods for monitoring the flow rate in intravenous therapy. Deep learning computer vision is a unique technique used to monitor the IV drip flow rate. In the case of pregnancy, there will be many psychological, emotional, and physical changes that make the woman fatigued, it may cause mild frazzles to severe exhaustion. Severe tiredness resulting from mental or physical exertion or illness is called fatigue. Endurable hydration is necessary for good health and needs support for all body systems, especially during pregnancy. A contemplative shortage of hydration leads to poor amniotic fluid production and organ malfunction, which results in abnormal infant growth. Therefore, a wearable body hydration sensor is used as a diagnostic device to diagnose the dehydration level and control fatigue. A wearable hydration sensor will be a safe tool to aid in hydration monitoring

***Index Terms* -** Intravenous infusion, Deep learning computer vision, Hydration, Dehydration, Wearable hydration sensor

## I. INTRODUCTION

Pharmacology is an eminent activity in clinical medicine for reckoning diseases. Assertion of fluids and other medications into a vein directly is called intravenous therapy. Delivering medicines and changing fluid throughout the body in the quickest way is the main advantage of Intravenous therapy [1]. In hospitals and medical care facilities, drip infusion solutions are commonly used. The infusion rate is measured every 1 hour or 30 minutes by a drop counter. IOT drip infusion system has an eminent monitoring system with a central monitor at the nurse station [2]. When the fluid level of the bottle reaches a cocksure limit an automatic intravenous drip monitoring system veraciously sends an alert message to the nurse. By means of a load cell, the system weighs the saline bottle to determine it’s weight and then transmits an automatic alerting and indicating device, known as GSM. The alert signal is transmitted by GSM [3]. It is prosaic to feel fatigued and even knackered during the first months of pregnancy. All women expertise fatigue in the early stage of pregnancy in the first trimester. In order to shape amniotic fluid, make extra blood, develop new tissue, transport nutrients, improve digestion, and flush out wastes and toxins, pregnant women require more water than the general population. During pregnancy, dehydration is a common issue. Whereas most cases of dehydration in pregnancy are vigorous and can be hazardous for both the mother and the baby. The baby puts a lot of demands on the body, therefore pregnant women need to eat a lot of extra nutrients and drink a lot of water. Dizziness and disorientation, a beating heart, and changes in the baby's rhythmic movement are all signs of dehydration during pregnancy. Poor amniotic fluid production and organ malfunction lead to abnormal infant growth these are due to a severe shortage of hydration. Adequate hydration is essential for good health and supports all body systems. There are detrimental health consequences they are dehydrated and therefore Headache, fatigue, and thirst are signs of mild dehydration, but fever, hypotension, a rapid heartbeat, increased breathing, cognitive decline, and even unconsciousness are signs of severe dehydration [4]. The presence of Na+, K, Cl, and compounds such as glucose, ammonia, and lactate in human sweat results from physiological situations linked to pathological sickness, salt consumption, drug addiction, heat exhaustion, and fitness-related factors, the structure of the sweat may vary. Consequences of dehydration are headache, vomiting, and, nausea, and if 12%-16% of fluids are lost in the body it can even induce death. A popular method of non-invasively monitoring human bodily parameters like hydration and salt loss is sweat structure tracking.

The current technology aims to provide a standardized electrochemical sensing system on the flexible material in the research area of wearable sensing technologies for continuous tracking of ionic components of bodily fluids permitting non-invasive accessibility towards human physiological data. A sweat storage region, a counter electrode, and an implanted reference electrode make up the patch material. These electrodes may be modified in the future to analyze other ions such as Cl, NH3, lactate, and glucose with ion-specific components [5].

## II INTRAVENOUS THERAPY

Crystalloid and colloidal solutions are administered intravenously during intravenous therapy. The type, volume, and infusion rates are fixed by the necessity for fluid treatment and the unique patient requirements [6]. Crystalloid solutions are used to revive dehydrated patients, modify ongoing fluid losses due to accurate free water deficits, and slake the thirst of patients who don't take fluids orally. Colloidal solution use is controversial and should only be used in certain circumstances (e.g., severe cases of low oncotic pressure). All patients must be regularly followed using a range of clinical markers, laboratory testing must be used to define therapeutic endpoints, and fluid therapy must be correctly de-escalated for patients in recovery to avoid fluid overload.[6].

### 2.1 Principles of IV Therapy

In hospital intervention, intravenous fluid management is crucial. Patients are given a lot of reasons why they need IV fluid therapy, which might prolong their illness and make their condition worse. Fluid resuscitation, Adjusting fluid deficits or free water deficits, Baseline fluid demand, Adjusting electrolyte imbalance, and IV drug therapy are a few of these. Parenteral fluid prescription involves the following 4Ds:Drug: Specify the type of liquid. Dosing: Specify the quantity and rate of fluids.Duration: Monitor the reaction and look at the shortest and longest possible treatment times. De-escalation: Reduce the intensity and eventually cut off the flow[7]

### 2.2 Remote Infusion Monitoring

The current health care system in the modern world relies on manual caregivers, whose enormous responsibilities contribute to social problems and demand a lot of time to complete. The system has a control system, a central monitor, and several infusion monitoring devices. The drip infusion monitor uses an IR sensor to calculate the drip infusion rate (drops per minute). At a specific critical set level, an empty infusion solution bag indicates the amount of remaining infusion capacity that is displayed on a central monitor. This information is wirelessly transmitted to the central monitor that is kept in the nurse's control room, where it is used to calculate the drip infusion rate. from a central monitor, the nurses can manage the machine. The central monitor gathers data from several infusion monitoring systems[2]

The infusion monitoring system uses a Bluetooth module to monitor the drip infusion rate and an empty infusion solution bag, and the information is sent to a central monitor at the nurse station. The main monitor graphically displays data from various infusion monitors [8]

System for Monitoring Intravenous Drip [2], [9]. In this technique, the notification is automatically transmitted via GSM technology. By using this technology, the nurse can focus on other tasks rather than constantly inspecting an IV fluid system. The Arduino Uno R3 forms the center of the mechanization circuit, which is operated by a solenoid valve to stop the fluid drop system. The time required for the control system can be reduced, and the system can be effectively controlled by using Arduino hardware. This allows nurses to support the healthcare system [9]

### 2.3 Computer vision system monitoring of drip infusion

The IV drip infusion set and processing equipment must be filmed using a standard camera [10]. One processing unit is used to evaluate video feeds coming from various cameras, To maintain the system adaptable and simple to deploy in already-existing healthcare facilities or patient homes, videos captured by cameras are delivered over a wired or wireless network connection [11],[13]. To interpret the drip films, deep learning computer vision techniques were compared to snake and closure algorithms [14]; they are often significantly more effective against interruptions and incorporate background texture, illumination, and focus difference. Deep learning systems can be trained on enormous datasets to improve performance, but computer vision algorithms can't.

#### 2.3.1 Object Detection with a Neural network

The GoogLeNet classification model [16] served as the inspiration for the deep learning model utilized for object detection, which is a fully convolutional neural network [15]. The neural network receives an input RGB image of any size, which is then shrunk to 416416. From the first to the last layer of the network, the output of the convolutional layers and the features map becomes more conceptual. The final layer output is a 13 by 13 matrix with four parameters to indicate the bounding box of the identified object and probability scores for each class of objects the model can perceive (one in this case) [10].

#### 2.3.2. Training object detection Models

A dataset of drop images generated from a collection of films of a drip infusion set was used to run the deep learning model. As can be seen in the frames that were taken from these videos, the drip infusion set was photographed under various lighting and background situations. The films were captured with a standard camera at a frame rate of 30 frames per second and a resolution of 1920 by 1080. [10]

#### 2.3.2 Drop tally

A thresholding mechanism processes the output of the neural network that was previously sent to offer only a list of observed bounding boxes with a corresponding probability score for each frame. A straightforward approach is used to further process the obtained binary signal, enabling accurate real-time drop counting even when some frames are mistakenly identified as lacking drops. When a frame with a drop is discovered and no drops are found in the next 10 frames, the drop count gradually rises. [10] This method, which uses deep learning computer vision for IV drip monitoring and delivers good accuracy, is less intrusive than other common alternatives that need direct interaction with the infusion equip.

## III FATIGUE IN PREGNANCY

Fatigue is defined as a lack of energy. Fatigue is also a retort to physical and mental activities [17]. Depending on the factors that contribute to it, fatigue can be classified as active, passive, or sleep-related [18]. Fatigue is a premature sign in pregnancy, nearly all women experience it in the first trimester. It is also very customary in the third trimester. During pregnancy, women require more water to flush out waste products and poisons, create new tissue, produce more blood, form amniotic fluid, and convey nutrients. Staying hydrated and drinking fluids is significantly vital to stay healthy during pregnancy [19].

## IV DEHYDRATION

All patients experience the effects of dehydration. Dehydration causes various health issues and can result in serious sickness. By restoring the lost fluid, dehydration can be cured [20]. Through the skin, lungs, kidneys, and GI tract, body water is retained. The loss of body water without sodium is what leads to dehydration. Skin, lungs, the digestive system, and kidneys all retain water [21]. Dehydration either results from or is caused by disease. Elderly people are more likely to get dehydrated due to immobility, poor thirst mechanisms, diabetes, renal illness, and falls [22],[23]. To support the body's many physiological processes, water is essential. 55% to 65% of the human body is water. Water is found in cells in two different ways: intracellularly and extracellularly. fifty percent of extracellular. Large amounts of water that can be removed from a person's body through continuous vomiting or diarrhea are dehydration causes. [24]. The reasons for dehydration are as follows: The digestive tract is inflamed, and the condition is referred to as gastroenteritis or "stomach flu." When one is toxic or abusing drugs, one's capacity to digest or absorb nutrients from food is reduced. Burns and fever. intense physical effort and perspiration. Severe urination can occur for a variety of reasons, including uncontrolled diabetes and prescription use, such as diuretics. Adrenal insufficiency, another term for Addison’s disease, happens when the body isn't ready for certain hormones.

SYMPTOMS: Dehydration symptoms can change over time and from person to person. Dehydration has no symptoms in the early stages, although mild to moderate dehydration can cause symptoms to appear. Dehydration can in some situations result in serious symptoms. Increased thirst, a dry or sticky mouth, constipation, little or no tears, and more are some of the symptoms. Tiredness, dry skin, headache, vertigo, Fast breathing, less frequent urination, or urine that is dark yellow in colour. rapid heartbeat

### 4.1 Wearable hydration sensor

A portable body moisture sensor was tested on 240 human volunteers, with an equal number of men and women, employing photoplethysmography and galvanic biosensors [4]. To track and check the sweat constantly, sweat complexity measurements and sweat bio-markers require a group of wearable molecular devices that can interface with the skin directly. Today, data are transmitted to the owner via Bluetooth, and in cases where it needs to be shared with a doctor, it is done so via the internet. In this review, we examine the various techniques used to create systems with such practical capabilities as the illustrated biosensor, wireless transmission method, electronics module, and designing for systems [5][24].

#### 4.1.1 Models for wearable sensing

The skin interface of the sweat sensor must have a quick response time, be extremely sensitive and precise, be durable in other climatic conditions, and have the best possible electricity efficiency. Nanotechnology has allowed for the miniaturization of sweat sensor technology, which is highly sensitive to measurements of sweat's extremely low concentration levels. The wearable sensor offers working electrodes in which the analyte is required to undergo an electrochemical reaction, as well as a reference electrode for measuring the potential of the working electrode and a counter electrode that provides the wearable sensor with a current collector [5][25][26].

#### 4.1.2 Materials that can be worn and incorporating substances:

Human skin's surface epithelium is extremely smooth and curved, and it has neither a constant nor malleable shape. However, materials used in electronics and electrochemical sensors, such as fiberglass, silicon, and glass, have hard and brittle physical properties. Wearable hydration sensors are made from soft embodying materials and complementary materials to carry out crucial duties in achieving acceptable comfort, strong signal reliability, and waterproof skin [5]. These materials, which are classified as substrates, top layers, and wearable sensor-like skin coatings, have textiles with an incredibly low young modulus, flexible plastics, and unique polymers that are highly elastic like rubbers [29,30]. The diverse materials include screen printing, polyethylene terephthalate (PET), polyester (PF), polydimethylsiloxane (PDMS), polyimide (PI), and inkjet temporary tattoo paper.

## V SENSING BODY DEHYDRATION

Total body water provides a measurement of the body's water content as a proportion of total body weight (TBW). The body's immediate level of hydration can be determined by bioelectrical impedance measurement and is connected to TBW. Deurenberg developed a prototype that links TBW volume to the impedance at 50 kHz (Z50), age in years (A), sex (S, 1 for male, 0 for female), and height in centimeters (H) as follows: [31] TBW is calculated as

6.53 + 0.3674 H2/Z50 + 0.1753 W - 0.11 A + 2.83 S.

The skin assumes the impedance of the skin at 50 kHz. Due to its reasonable sensitivity to changes in body composition and the lower likelihood of false positives, it is significant for testing frequency in bioimpedance analysis.

### 5.1 Specifications and description of the prototype:

The system may be broken down into three primary parts: dehydration detection, impedance reading, and AC signal generation The Atmel ATtiny85 microprocessor has been chosen because of its small size and low power consumption. The CPU in the initial iteration registered through SPI to a digital to analog converter (MCP4901 8-bit DAC) while operating a look-up table of sine wave values. This produced a pure 3V sine wave, but the device was unable to generate high-frequency signals because of software limitations. Later variations operated a square wave only using the CPU. The most ideal design would probably incorporate IC components developed exclusively for sine wave generating. [31-34]. Using its internal 10-bit analog to digital converter, the ATtiny85 determines the output voltage of the skin-load divider. Calibration data is endured and saved in the CPU during system startup and/or reset. A running average algorithm develops the AC signal and looks for the wave peaks to determine the size of the output response. If the user's hydration level has decreased noticeably enough to be considered dehydrated, threshold logic determines this. The gadget periodically cycles through this polling process and a sleep cycle during which it enters low power mode to preserve battery life. A 3k load resistor is selected. The gadget displays two LEDs. There is a yellow LED indicator on when the device is powered up and operational. The microcontroller turns on a red indicator LED when it detects dehydration [35,36].

### 5.2 Body dehydration sensor experiment results

R skin = 284 and C skin = 86 nF represent hydrated skin, which is equivalent to normal skin in terms of capacitance. R skin = 298 and C skin = 80 nF are valued for skin that is dehydrated. These values could be used to measure the response of an emulated circuit using discrete resistors and capacitors. This serves as a benchmark for impedance readings obtained from human skin [31].

## VI. CONCLUSION

Utilizing a computer vision system for remote infusion drip has many benefits, including modularity and adaptability to various working environments. It can be set up to gather and analyze video streams coming from nearby or distant sites. The use of deep learning algorithms increases the computation method's versatility and adaptability to changing environmental variables. Additionally, medical staff can receive immediate visual feedback when a problem is identified, such as a change or halt in the drop flow [37–39]. Research on adaptable and flexible materials, the creation of various solid-state electrodes, and the development of microfluidics technology—all of which could serve as skin interfaces—is where sweat sensing is now headed in the wearable technology world. To expand sensing capability and create models with more accuracy and resilience, more study is required on the subject of wearable sensors and instruments. Accuracy, comprehensiveness, and robustness are the three primary advancements that will shape the dehydration sensor's future. The device's initial iteration showed promising accuracy in somewhat sedentary, controlled situations [40]. Thus, a wearable hydration monitoring watch can help us further this technology. For expectant women, this will provide notification of body updates [41]. It is incredibly simple, dependable, and easy to use. The patient can easily access it through Bluetooth, a wireless technology that is portable for the patient. This method helps expectant women maintain water levels and improved metabolic activity.

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