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Implementation of a digital orthopedic joint surgical device

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ABSTRACT: This study consists of a handgun type spectral analysis, position correction, and viewing window, and the structure of the endoscope device is composed of an endoscope connector, a universal cord, a control section, and an insertion tube. When using an ultra-wide-angle lens, an image sensor, and a general light source, it is driven by an LED, and a filter that can express the brightness of lesions and general tissues differently through near-infrared spectral analysis of a 700-1,100 nm LED short wavelength was selected to enable color expression of near-infrared light. Position correction was difficult to interpret because the direction of gravity in the image acquired from the video endoscope equipment did not match the direction of gravity in the working space.

Using an accelerometer and a gyro sensor, the direction of gravity of the endoscopic image is always corrected so that the screen is in the designated position. The image obtained from the correction process is used to detect abnormal areas and facilitate the extent of the affected area's progression. A large image monitoring and viewing window is attached to the main body so that the medical staff can easily view it in real time on a small LCD screen directly attached to the arthroscope during surgery, and the detected specific symptom images are automatically stored and analyzed in a database. In wireless communication, a digital electronic camera module and a UWB communication module that transmits high-quality image information sensed by the endoscopic equipment are combined, and a wireless image communication system that uses UWB-based communication with a monitor connected to the transmitter is established, high-quality endoscopic management information is wirelessly transmitted to the UWB communication module and played on a PC on the wall of the operating room, and the endoscopic video stored in the memory of the digital electronic camera module is wirelessly transmitted through the UWB communication module.

KEYWORDS: Orthopedics, joint surgery, spectroscopy, position correction, arthroscopy

I. INTRODUCTION

In the case of digital endoscopes, LEDs are used as low-power light source elements, and a constant current LED driver is designed for stable operation of the LED, and it must be designed in a cylindrical shape, and because the diameter is narrow, it cannot be mounted on a single PCB, so it is designed to be implemented in a laminated manner. It has a built-in power supply, and a structure that can be operated by receiving power from a power control module, and a device for controlling the light source to identify abnormalities in tissues is performed using an arthroscope that utilizes the fluorescence properties of tissues.When a light source in the near-ultraviolet range of 375 to 478 nm is projected into the body, the tissues in the body naturally fluoresce, and the difference in fluorescence is shown depending on the chemical characteristics of abnormal and normal tissues, and this is visualized to distinguish the tissues.

Electronic endoscopes are the most commercialized endoscopes, and they consist of an insertion section that enters the body to receive images, a control section for adjusting the insertion section, a connection section that connects the image center and the light source device, a processing section for processing image signals, and an output section for outputting processed images.The received images are transmitted to a monitor by the image signal processing unit, which is a signal processing unit, and output. Electronic endoscopes can perform both examinations and treatments from real-time images using high-resolution, miniaturized CCD chips.

Images transmitted from the CCD chip can be output to a monitor and stored as medical diagnostic data using a photographic device or video printer.The endoscope power control module is a circuit that supplies power to digital endoscopes, and is designed to supply power to image sensors, image processors, communication modules, LED FLUs, etc.It is a handgun type with a view window attached to the body for easy use, and it maintains an improved horizontal level by utilizing a gyro scope, etc.In addition to the components mentioned

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above as the minimum components for making a digital endoscope, various other components are the design, and among the additional components that require a power source, many Op-Amps are also used.
Depending on the purpose, it can be connected to a PC and USB port, and a BNC port is built in so that it can be directly connected to equipment such as an
oscilloscope or spectrum analyzer. This module was designed to measure the performance of wired/wireless UWB communication modules.

II. Materials and Methods

In sensing using a digital electronic camera, high-definition endoscopic information is transmitted wirelessly to the UWB communication module and played on a PC, and the endoscopic video stored in the memory of the digital electronic camera module is transmitted wirelessly through the UWB communication module[1].

Medical staff can conveniently play high-definition image information of the endoscope on the display wirelessly, and UI structure and UI SW for analysis and monitoring of image data are implemented using a near-infrared light filter, and it is easy to find unusual symptoms such as abnormalities and inflammation in the patient's affected area[2].The unusual symptoms of the affected area were determined by applying the near-infrared wavelength range that can distinguish abnormal tissues and normal tissues in the body through near-infrared spectroscopy analysis to the filter.In this study, we developed a device that corrects the gravity direction of the endoscopic image so that the screen is always in the designated location using an accelerometer and a gyro sensor, and developed an image processing algorithm to detect abnormal areas and quantify the extent of the affected area using the acquired image, and verified it using arthroscopic images[3].It outputs to a large-scale image monitoring and a small LCD screen directly attached to the arthroscope, allowing real-time viewing on a dual display screen, and automatically saves detected specific symptom images and then creates a database for analysis[4].

III. System Composition and Principal

Figure 1 Wireless arthroscope with handgun type spectral analysis, position correction, and view window. Figure 1 shows the method proposed in this study[5]. When used as a general light source, it is required for

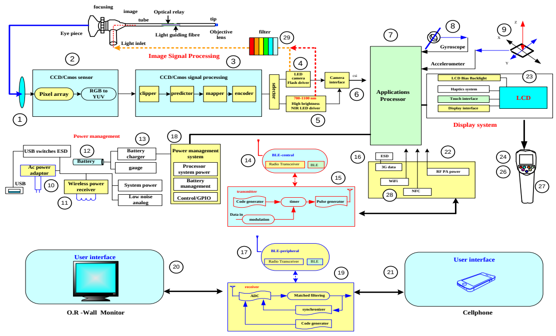

Figure 1 Wireless arthroscope with handgun type spectral analysis, position correction, and view window.

The near-infrared wavelength range was determined so that it can be easily replaced by filter when necessary, and the jack type was used for convenience.Position correction was used to use the acquired image in the correction so that the gravitational direction of the endoscopic image is always at the designated location using an accelerometer and gyro sensor in the acquired image[7].

A large image monitoring and view window is attached to the main body so that the medical staff can easily view it in real time on a double display screen by outputting it to a small LCD screen that can be directly attached to the arthroscope during surgery, and the detected specific symptom images are automatically saved and then analyzed in a database[8].In wireless communication, a Bluetooth (small capacity) and UWB (large capacity) communication module that transmit high-quality image information sensed from a digital electronic camera module and an endoscope equipment were combined, and a wireless image communication that uses UWB-based communication with a monitor connected to the transmitter was established[9].

In sensing using a digital electronic camera, high-quality endoscopic image information was wirelessly transmitted to the UWB communication module and played on a PC on the wall of the operating room, and the endoscopic video stored in the memory of the digital electronic camera module was wirelessly transmitted via the UWB communication module[10].Symbol 1 is a lens, symbol 2 is a CCD-CMOS sensor, symbol 3 is a CCD-CMOS sensor signal processing, symbol 4 is a general lighting LED, symbol 5 is a near-infrared LED

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driver with a wavelength of 700-1,100 nm proposed in this study, symbol 6 is a camerainterface, symbol 7 is an application processor, symbol 8 is a gyroscope sensor that performs the position correction function proposed in this study, symbol 9 is an accelerometer that controls the speed of the position correction and attitude correction proposed in this study, symbol 10 is an AC adapter, and symbol 11 is wireless power[11]. Symbol 12 represents the battery of wireless arthroscopy, symbol 13 represents the battery charger, symbol 14 represents the small data transmission and reception bluetooth transmitter of the auxiliary concept, symbol 15 represents UWB-T, symbol 16 represents the wifi module, symbol 17 represents the small data transmission and reception bluetooth receiver of the auxiliary concept, symbol 18 represents the power management system, symbol 19 represents UWB-R, symbol 20 represents the OR-wall monitor, symbol 21 represents the cell phone, symbol 22 represents RF power.Symbol 23 represents the hand gun type LCD view proposed in this study, symbol 24 represents the LCD view proposed in this study, symbol 25 represents the control button of the hand gun type proposed in this study, symbol 26 represents the handle battery storage of the hand gun type proposed in this study, symbol 27 represents the hand gun type handle battery storage of the proposed study, symbol 28 represents NFC, symbol 29 represents the filter proposed in this study[13].

IV. Practal Analysis and Implement

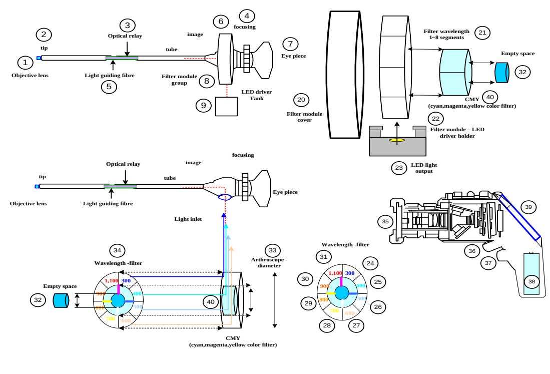

Figure 2 Wireless arthroscopy with spectral analysis and blocking filter and view window

Figure 2 Wireless arthroscopy with spectral analysis and blocking filter and view window.Basically, the light source is generated using LED, and the light source generated from the light source is equipped with an ultraviolet blocking filter and a CMY (Cyan, magenta and yellow) color filter on the light source lamp and scope[14]. Ultraviolet rays can cause deformation of cells in the body, and the color filter is for correcting CMY, and the image signal is corrected by sequentially rotating the three color filters. Symbol 1 is the objects lens, symbol 2 is the tip, symbol 3 is the optical relay, symbol 4 is focusing, symbol 5 is the light guide fibre, and symbol 6 is the method proposed in this study, which is a high-power light source that emits near-infrared light, and the inside holds the arthroscope axis, and the next is composed of a colorfilter[15]. The next is composed of an ultraviolet filter, etc. Symbol 7 is an eye piece, symbol 8 is a filter module group, symbol 9 is an LED driver that can output up to near-infrared wavelengths, symbol 20 is a filter module cover, symbol 21 consists of 8 filter wavelengths from 300 to 1,100.Symbol 22 is a filter module LED driver holder, symbol 23 is a high-power LED light output, symbol 32 is an empty space, and symbol 40 is a CMY filter (cyan, magenta, yellow).Symbol 34 is a wavelength filter, symbol 33 is an arthroscope diameter, symbol 24 is a blue filter, symbol 25 is a 300 nm, symbol 6 is a 500 nm, symbol 27 is a 600 nm, symbol 28 is a 700 nm, symbol 29 is an 800 nm, symbol 30 is a 900 nm, and symbol 31 is a 1,100 nm filter.Symbol 35 is symbol 7 holder, symbol 36 is zoom-in switch in the method proposed in the present invention, symbol 37 is zoom-out switch in the method proposed in the present invention, symbol 38 is high-capacity arthroscopic battery in the method proposed in the present invention, symbol 39 is LCD-view window in the method proposed in this study[16].

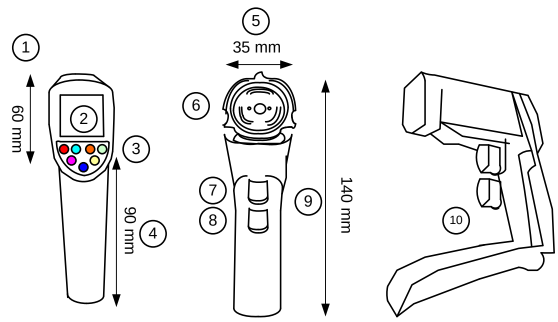

Figure 3 Wireless arthroscope with handgun type VIEW WINDOW configuration

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Figure 3 Wireless arthroscope with handgun type VIEW WINDOW configuration, size, and function

Figure 3 is handgun type in this study, symbol 1 shows the approximate size of the integrated VIEW WINDOW, and symbol 2 shows LCD VIEW WINDOW. Symbol 3 shows various CONTROL buttons, symbol 5 shows the width of the Symbol 9 represents the handle length of the handgun wireless arthroscope, and symbol 10 represents the battery insertion space of the wireless arthroscope[17].

V. Experiment Results

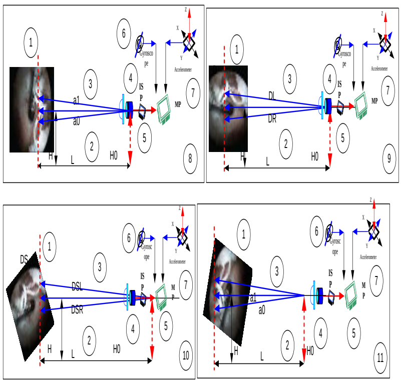

Figure 4. Image position correction of acceleration and gyroscope sensors

Figure 4. Image position correction of acceleration and gyroscope sensors.For three-dimensional compensation, one gyroscope is required for each axis of rotation, and in the case of a high-precision gyroscope, it is used for navigation purposes by integrating the acceleration measured in the three-axis reference coordinate system together with an accelerometer that measures linear acceleration to obtain speed, distance, and position[18].The Coriolis force, called the Coriolis force, is a force that appears on a rotating object, and its intensity is proportional to the speed of the object, and the direction of the force acts perpendicular to the direction in which the object is moving.Figure a) shows the concept of a screen where angular velocity and gyroscope are applied to distance, Figure b) shows the concept of angular velocity and gyroscope applied to height, Figure c) shows the concept of angular velocity and gyroscope applied to a horizontal screen, and Figure d) shows the concept of a screen where angular velocity and gyroscope are applied to a non-horizontal screen. Symbol 1 represents the screen of the arthroscope, symbol 2 represents the length, symbol 3 represents the length seen from the left, symbol 4 represents the lens, symbol 5 represents the image signal processor, symbol 6 represents the gyroscope sensor, and symbol 7 represents the accelerometer[19].

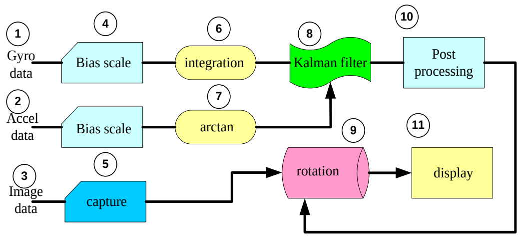

Figure 5 Image position correction of the Kalman filter

Figure 5 Image position correction of the Kalman filter.The sensor used is the 3-Space Sensor Bluetooth (Yost Engineering Inc., Portsmouth, United States), which includes a 3-axis accelerometer, a 3-axis gyro, and a 3-axis geomagnetic sensor[20].The measurement values of the two inertial sensors are corrected using the Kalman filter to determine the final rotation angle, and the result values after the Kalman filter go through a postprocessing process, which compensates for the speed difference between the image acquisition device and the sensor device.The computer program that obtains the rotation angle of the endoscope device using the measurement values received from the accelerometer and gyro sensors and then rotates the endoscope image in real time and displays it on the monitor was developed to run on the Windows operating system using Microsoft Visual Studio[21].

In the results of this study, in the case of wireless connection, the integration error of the gyro sensor accumulates over time and the value becomes inaccurate, but this is solved with a wireless sensor with a fast operating speed. Symbol 1 represents gyro data, symbol 2 represents accelero data, symbol 3 represents image data, symbol 4 represents bias scale, symbol 5 represents capture, symbol 6 represents integration, symbol 7 represents arctan, symbol 8 represents kalman filter, symbol 9 represents rotation, symbol 10 represents post processing, and symbol 11 represents display.

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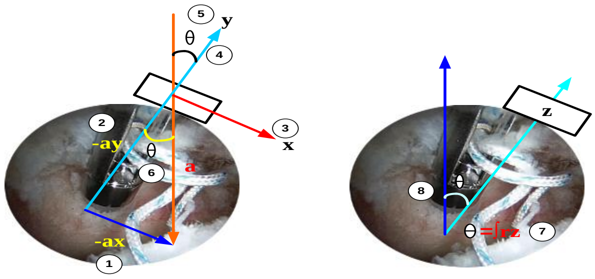

Figure 6 Image position correction in rotation angle using a sensor

Figure 6 Image position correction in rotation angle using a sensor .The magnetic field sensor has a measurement unit of micro-Tesla (uT), so it has the disadvantage of being sensitive to environmental factors, and frequent correction is required to obtain accurate measurement values[22]. The gyro sensor is a sensor that shows the average angular acceleration per unit time, and shows different values depending on the control axis, and uses three orthogonal axes as the control axis, and this is widely used for attitude correction of moving objects such as airplanes[23]. In the axis and rotation angle of the inertial sensor attached to the endoscope, symbol 1 represents -ax, symbol 2 represents -ay, symbol 3 represents the x-axis, symbol 4 represents the y-axis, symbol 5 represents the angle θ, symbol 6 represents the gravity axis angle θ, symbol 7 represents θ=integral rz, and symbol 8 represents the external axis of θ[24].

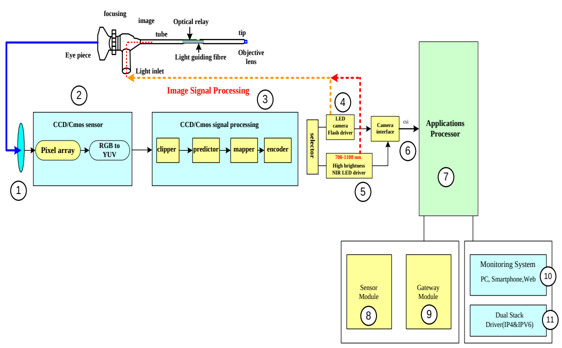

Figure 7. Hardware system of wireless arthroscopy in Bluetooth image processing

Figure 7. Hardware system of wireless arthroscopy in Bluetooth image processing[25]. It can measure arthroscopy continuously and in real time, and can display it on Or-wall monitor and view window for feedback of arthroscopy[26]. It can support IPv6 in preparation for the IoT era, and it should be connected to the Internet to build an arthroscopy information database, capable of processing large amounts of data, easy to move and use, and consume less power. Symbol 1 represents the lens of the arthroscopy, symbol 2 represents the CCD CMOS sensor, symbol 3 represents the CCD CMOS signal processing, symbol 4 represents the LED camera flash driver, symbol 5 represents the NIR LED driver with a wavelength of 700-1,100 nm, symbol 6 represents the camera interface, symbol 7 represents the application processor, symbol 8 represents the sensor module, symbol 9 represents the gateway module, symbol 10 represents the monitoring system, and symbol 11 represents the dual stack driver[27].

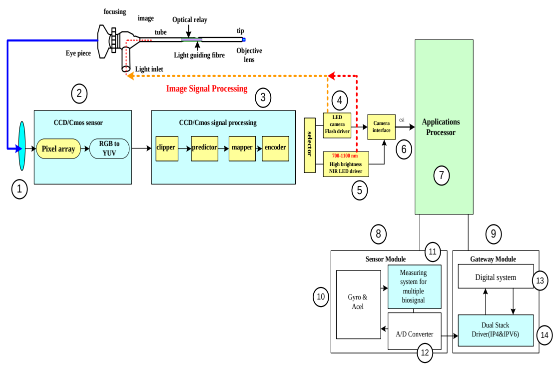

Figure 8. Sensor and gateway module of wireless arthroscope in Bluetooth image processing

Figure 8. Sensor and gateway module of wireless arthroscope in Bluetooth image processing . The hardware section is largely divided into sensor module and gateway module, and the sensor module consists of sensor block and control and transmission block as shown in Figure 8[28]. The gateway module connects the received biosignal to the Internet using TCP/IP communication based on IPv4 or IPv6. The sensor module consists of gyro sensor block, accelero sensor block, and geomagnetic sensor block. Symbol 1 is the lens of the arthroscope, symbol 2 is the CCD CMOS sensor, symbol 3 is the CCD CMOS signal processing, symbol 4 is the LED camera driver, symbol 5 is the 700~1,100nm high brightness NIR LED driver, symbol 6 is the camera interface, symbol 7 is the application processor, symbol 8 is the sensor module, symbol 9 is the gateway module, symbol 10 is the gyro & accel sensor, symbol 11 is the measuring system, symbol 12 is the A/D converter, symbol 13 is the digital system, symbol 14 is the dual stack driver[29].

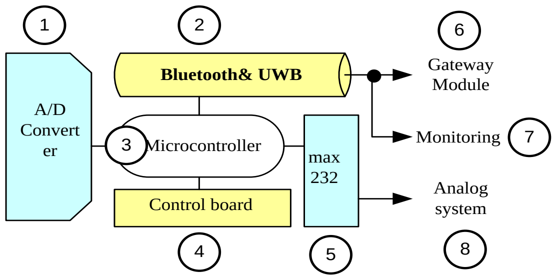

Figure 9 Control and communication module of the wireless arthroscope

Figure 9 Control and communication module of the wireless arthroscope. The configuration of the control and communication module of the wireless arthroscope is as shown in Figure 9. MSP430 (TI) was used for the microcontroller, and MSP430 has a 6-channel 12-bit ADC, so 3 of these channels were used to use the gyro, accelero, and geomagnetic sensors, and each was converted to 512Hz 12bit. Symbol 1 is the A/D converter, symbol 2 is Bluetooth (UWB), symbol 3 is the microprocessor, symbol 4 is the control board, symbol 5 is max232, symbol 6 is the gateway module, symbol 7 is monitoring, and symbol 8 is the analog system connection interface.

VI. Discussions

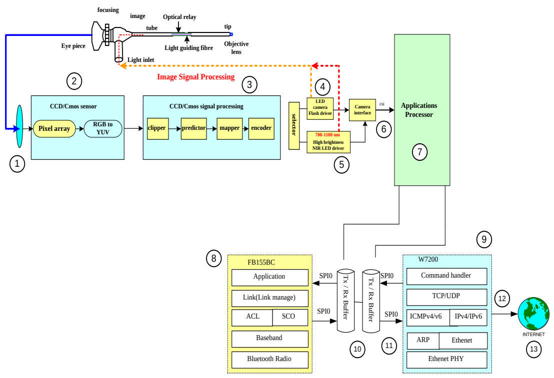

Figure 10 Wireless arthroscopy with simple image processing using gateway module

Figure 10 Wireless arthroscopy with simple image processing using gateway module. The protocol structure for transmitting image signals to the Internet using the gateway module for image processing is as shown in Figure 10. Symbol 1 represents the lens of the arthroscopy, symbol 2 represents the CCD CMOS sensor, symbol 3 represents the CCD CMOS signal processing, symbol 4 represents the LED camera driver, symbol 5 represents the 700~1,100nm high brightness NIR LED driver, symbol 6 represents the camera interface, symbol 7 represents the application processor, symbol 8 represents the bluetooth fb155bc, symbol 9 represents the protocol stack w7200, symbol 10 represents the tx/rx buffer, symbol 11 represents the tx/rx buffer, symbol 12 represents the protocol stack, and symbol 13 represents the Internet.

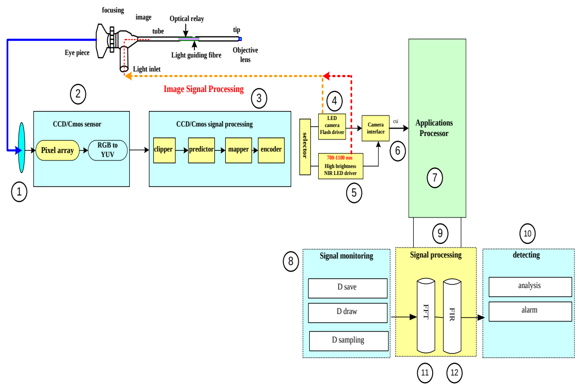

Figure 11 Monitoring program and operating program of wireless arthroscopy

Figure 11 Monitoring program and operating program of wireless arthroscopy. The software section consists of the monitoring program and the operating program, and the monitoring program implements the PC version, smartphone version, and web version. The FFT module is implemented to process time series data in the frequency domain, and the FIR module is implemented to process biosignals in real time as a digital filter. The PC version software was developed using Visual Studio 2010 (Microsoft). Symbol 1 is the arthroscope lens, symbol 2 is the ccdcmos sensor, symbol 3 is the ccdcmos signal processing, symbol 4 is the LED camera driver, symbol 5 is the 700~1,100nm high brightness NIR LED driver, symbol 6 is the camera interface, symbol 7 is the application processor, symbol 8 is the signal monitoring, symbol 9 is the signal processing, symbol 10 is the detecting, symbol 11 is the FFT, and symbol 12 is the FIR function.

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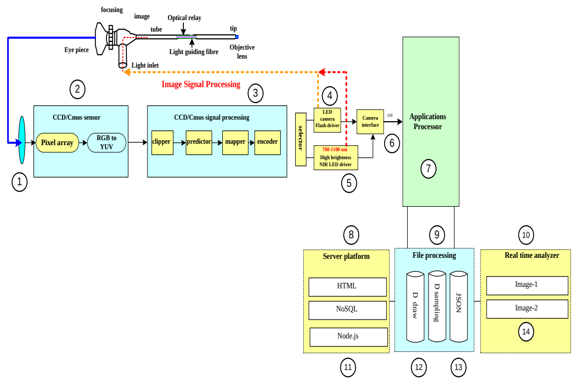

Figure 12 Web version monitoring program for wireless arthroscopy

Figure 12 Web version monitoring program for wireless arthroscopy. The web version monitoring program structure is as shown in Figure 12, and the server platform was built using Node.js, NoSQL, and HTML5.0.

Auto-configuration for IPv4 and IPv6 first checks whether it belongs to an IPv6 environment, and if not, it basically operates in an IPv4 environment. If it belongs to an IPv6 environment, it checks whether it is set manually or automatically, and if it is set automatically, it performs the IPv6 Auto-configuration process to allocate an IPv6 address.

TCP server mode waits for a SYN message from the client after opening a socket, and responds when it receives a SYN message. It establishes a connection and performs the function of sending and receiving data through a 3-way handshaking process.

TCP client mode opens a socket, sends a SYN message to the server, receives a response, establishes a connection, and then sends and receives data. Symbol 1 is the arthroscope lens, symbol 2 is the CCD CMOS sensor, symbol 3 is the CCD CMOS signal processing, symbol 4 is the LED camera driver, symbol 5 is the 700~1,100nm high brightness NIR LED driver, symbol 6 is the camera interface, symbol 7 is the application processor, symbol 8 is the Sserver platform, symbol 9 is the file processing, and symbol 10 is the real time analyzer function.

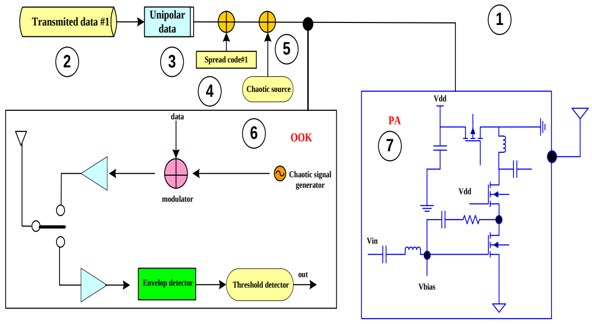

Figure 13 UWB (Bluetooth) transmission processing in arthroscopic images

Figure 13 UWB (Bluetooth) transmission processing in arthroscopic images. UWB systems transmit binary data as carrier-free using impulses, and transmit a large amount of information signals using a pulse train structure that continuously generates pulses rather than a single pulse used in radar. UWB-based communication technology and channel modelling applicable to endoscopic equipment are ultra-wideband modulation and demodulation technology using chaotic sources and chirp signals, and chaotic UWB can generate carrier signals very simply by using chaotic sources as carriers and performing code multiplexing based on OOK (On Off Keying) modulation. The receiver structure can also be simplified like the transmitter, making it suitable for WBAN that must accurately transmit low-speed data. Basically, the load stage is configured as an R-L resonance section, and an inductor is inserted into each of the input and output of the cascode to increase the gain in the upper band.

By adding one transistor in parallel to the first transistor of the cascode stage, the gain drop in the lower band is compensated for, and a resistor is placed between the body and source of the transistor of the cascode stage to design a low noise figure value in the entire band. Symbol 1 represents the entire receiver, symbol 2 represents transmitted data, symbol 3 represents unipolar data, symbol 4 represents spread code, symbol 5 represents chaotic source, symbol 6 represents QQK modulation, and symbol 7 represents PA.

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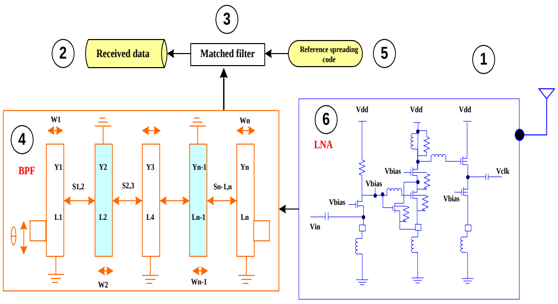

Figure 14 UWB (Bluetooth) reception wireless arthroscopy in arthroscopic images

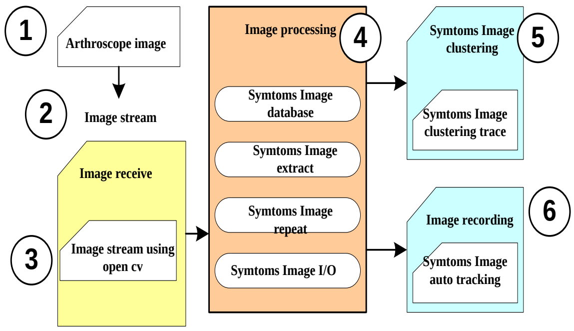

Figure 15 Real-time image monitoring in arthroscopic images

Figure 14 UWB (Bluetooth) reception wireless arthroscopy in arthroscopic images. The transmission speed in the UWB system is 100 Mbps, and in the frequency domain, the power spectrum is densely concentrated in a certain frequency band, and high-power pulses are generated in a short time, but since the width is very narrow, the energy is dispersed over a wide band, so the spectrum power density is very low. It shows an average output of 1/100 of that of a mobile phone or WLAN, and is a type of baseband communication through encoding.

Since it transmits signals as a carrier wave without frequency modulation using a carrier wave, a linear amplifier is not required if high-power communication is not performed, and the system structure is very simple because an intermediate frequency section is not used.

Since it uses time division multiple access, it is possible to provide wideband services for multiple users, and since the signal is distributed over a wide band, it is suitable for short-distance communication, making it suitable for medical devices. Symbol 1 represents the UWB reception concept, symbol 2 represents the receiver, symbol 3 represents the matched filter, symbol 4 represents the band puse filter, symbol 5 represents the reference spreading code, and symbol 6 represents the LNA.

Figure 15 Real-time image monitoring in arthroscopic images. The image monitoring image receiving unit stores the image sent from the endoscopic camera in the computer's memory and transfers the data to the image processing unit so that the image processing unit can process the image in real time. The image processing unit receives the frames of the image transmitted in real time, distinguishes the background image from the specific symptom image, and applies the image processing algorithm to track the specific symptom.

The clustering unit, which clusters multiple specific symptoms, identifies all the ranges captured as specific symptoms, assigns numbers in order, and performs the clustering task of arranging them in memory.

The number assigned by the clustering task continues to move along the specific symptom until the abnormal movement of the specific symptom that transmits high-quality image information sensed by the endoscopic equipment are combined, and a wireless image communication that uses UWB-based communication with a monitor connected to the transmitter is established. disappears. The recording unit, which saves the movement of the specific symptom as a file, saves the image with the movement of the specific symptom and the image processing algorithm applied as a file on the computer when the doctor who was monitoring the image gives a recording command to analyze the current movement of the specific symptom in more detail. Symbol 1 represents arthroscope image, symbol 2 represents image stream, symbol 3 represents image receive, symbol 4 represents image processing, symbol 5 represents symptoms image clustering, and symbol 6 represents image recording.

VII.Conclusion

It has a handgun type spectral analysis and position correction and a view window, and the structure of the endoscope device is conveniently composed of an endoscope connector, a universal cord, a control section, and an insertion tube.

When used as an ultra-wide-angle lens, an image sensor, and a general light source, it is driven by LED and performs near-infrared spectral analysis of the short wavelength of 700-1,100 nm LED.

By selecting a filter that can express the brightness of lesions and general tissues differently, infrared color expression is possible, and it is easy to distinguish abnormal tissues and general tissues in the body through spectral analysis of the affected area, and it is easy to replace each filter by determining the near-infrared wavelength range, and it is convenient as a jack type.

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