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Computer Vision

Based on the computer vision indoor positioning system, through the computer vision algorithm, using the positioning process of the camera to capture the image information and the pre-collected positioning venue visual photo database to do a comparison, so as to determine the position of personnel coordinates.

With the rapid development of artificial intelligence technology in recent years, the accuracy of indoor positioning system based on computer vision has been greatly improved, generally within 1 to 2 meters. Its disadvantages are obvious: if it is based on the active positioning of mobile intelligent devices, the pedestrian is required to always open the camera in the positioning process; If it is passive positioning, a large number of high-definition cameras need to be installed in the pavilion in advance, and the project cost is high.

Wi-Fi

Wi-Fi is a wireless local area network (WLAN) based on IEEE 802.11 standard. It has the characteristics of high bandwidth, high speed and high coverage, and is very little affected by non-line-of-sight (NLOS). In the application range of short and medium distance, WIFI has incomparable advantages. IEEE 802.11 standard is currently widely used in the installation of high-speed wireless broadband network. The mainstream 3C wireless network cards are all based on this series of products. Therefore, for WiFi positioning system, the hardware platform has been very mature.

For indoor environment, the multipath effect of WIFI is still unavoidable, so the positioning method based on signal attenuation model cannot be used. WiFi positioning system usually adopts a positioning scheme based on machine learning. This positioning scheme is divided into two stages: off-line stage, collect enough training data, establish environment model, and get the distribution of WiFi signals; In the online stage, real-time data are collected, the established model is imported, and the current positioning results are obtained.

Indoor Wi-Fi network can not only be used as general network infrastructure, but also can use its pathloss effect (pathloss) of spatial propagation to establish a pathloss model, so as to realize location data solution.

The advantage is that you can take advantage of Wi-Fi routing devices that are already deployed indoors without additional deployment. However, if the venue itself does not have Wi-Fi equipment, additional deployments will be required.

The disadvantage is that due to the complex structure of indoor space, there are shadowing and multipath effects in the process of radio wave propagation in indoor space. Therefore, it is difficult to establish a propagation model that can truly reflect the indoor space, no matter by model method or fingerprint method.

Therefore, the positioning accuracy of commercial Wi-Fi indoor positioning systems is generally about 15m to 25m, depending on the number and distribution of existing Wi-Fi devices in the room.

Bluetooth

Bluetooth is a short distance wireless communication technology specification, was put forward by Ericsson in 1994.

The technical features of Bluetooth include:

(1) Work in the ISM band, no license is required;

(2) The transmitting power is small, and has the self-adaptability, no electromagnetic wave pollution;

(3) Adopting Ad Hoc mode and no base station networking mode, self-organizing network can be easily realized;

(4) the use of fast frequency modulation technology (1600 /s), strong anti-interference ability;

(5) The fast confirmation mechanism can realize lower coding overhead when the link condition is good;

(6) CVSD speech coding, in the case of high error code can also work;

(7) Loose link configuration.

Based on the above technical characteristics, Bluetooth technology is very suitable for indoor positioning. Because Bluetooth devices are small and easy

It is integrated into PDA, PC and mobile phone, so Bluetooth indoor positioning technology is easy to popularize.

Generally, two measurement algorithms are used in Bluetooth-based positioning systems: the measurement method based on propagation time and the measurement method based on signal attenuation. For the former, due to the variable indoor environment, so there is multipath effect, in order to reduce the error must adopt nanosecond synchronization clock, but this is difficult to achieve in practical application. For the latter, there are two very different ways of thinking: The first idea is completely according to the theoretical formula (that is, the radio signal energy attenuation varies inversely as the square of the distance) to calculate, but as a result of actual application attenuation when the signal is affected by many factors, not only depends on the distance, so only according to the idealized model formula is deduced for positioning, the results are often not satisfactory; The second idea is to calculate based on the empirical positioning method. Before positioning, the signal strength of multiple reference points in the target area should be measured in advance, and a series of data should be built into the database. However, in actual positioning, the signal strength received by the mobile terminal can be matched with the above database to complete the positioning. The positioning accuracy of this method is closely related to the accuracy of database.

The iBeacon protocol launched by Apple and the Eddystone protocol launched by Google are the representatives of Bluetooth low-power technology in the field of indoor positioning. The positioning principle is similar to Wi-Fi technology. The advantage is that Bluetooth low-power devices consume less power and do not need additional power, relying only on button batteries. The average smart phone also has Bluetooth scanning capability. The disadvantage is that to achieve the positioning accuracy of 1-2 meters, a large number of beacon devices need to be deployed indoors.

RFID

RFID is a technology that sends electromagnetic signals through radio frequency integrated circuits and collects and stores them. RFID indoor positioning technology mainly consists of RFID tag, RFID reader two parts, is a non-contact automatic identification technology. RFID readers receive signals from RFID tags, and communication between them is completed using specific radio frequency signals and related protocols.

RFID tags can be divided into passive and active two categories.

Active RFID tag is a small signal transmitter, which can actively transmit information such as identity identification when receiving an inquiry signal. Its advantage is that it has only a short antenna, but at the same time it has a large signal coverage.

Passive RFID tags do not require power supply, but are driven by the RFID reader sent radio frequency signals, it will return to the RFID reader response information. Passive RFID tag is an alternative product of traditional barcode technology. Compared with active RFID tag, it has the advantages of lighter weight, smaller size and lower cost. However, the transmission distance of passive RFID tags is very limited, usually only 1 ~ 2m.

RFID tags are commonly used in logistics, retail, transportation, food, and security fields. IC cards, which are now widely used in urban bus systems and "smart cards" in schools, are RFID applications. The representative positioning system based on RFID indoor positioning technology is SPOTON positioning system. This system realizes 3D positioning by analyzing the received signal strength and using clustering algorithm. In addition, LANDMARC positioning system is also an outstanding representative of RFID indoor positioning technology, which uses the densely arranged reference nodes in the RFID network to achieve positioning. Different RFID systems may operate at different frequencies.

RSSI positioning method is often used in RFID positioning system because of the characteristics of short range sensing. In addition, the RFID reader is cheap, and the beacon nodes can be arranged in large numbers in the target area, and the nodes can be moved

Points only need to attach a RFID tag, therefore, RFID indoor positioning cost is low, has a great space for development. Specific implementation of positioning, can take the following two ideas.

(1) Real-time calculation based on signal propagation model. The closer the moving target is to the RFID reader, the greater its RSSI value will be, and vice versa. Therefore, according to the RSSI -- distance relationship, the distance between the mobile node and a certain reference node can be determined, and then within the overlapping coverage range of 3 or more reference nodes, According to the obtained RSSI value, the distance between the reader and the reference point is calculated respectively, and then the position of the mobile node is calculated according to the triangular relationship.

(1) It is difficult to find a robust propagation model, especially for the complex and changeable indoor environment, due to the inevitable influence of environmental factors in practical application. In practical application, RSSI database construction method is usually adopted, that is, the RSSI value of multiple reference points in the target area is collected in advance, and then the fingerprint database about the location information is established. In this way, during the actual positioning, the mobile node receives the RSSI value of the reference node and carries out relevant operation with the established database. The e location information corresponding to the value with the greatest correlation is the location result.

Its advantages are high data transmission rate, good security, and free from the problem of non-line of sight communication.

Its disadvantage is that a large number of RFID devices need to be deployed in the positioning area, and the positioning personnel need to hold RFID tags, therefore, it has not been promoted on a large scale in the field of indoor positioning.

Zigbee

ZigBee is made up of two English words: "Zig" and "Bee." "Zig" in Chinese means "zigzag" path, and "Bee" translates as "Bee." ZigBee wireless sensor network technology is to transmit information from one node to another node in the distance through the mutual transmission of information between network nodes by imitating the way that bees dance. ZigBee is a low rate wireless communication specification, which is based on IEEE 802.15.4 physical layer protocol and MAC layer protocol. ZigBee's network layer, application layer, and additional developed security layer protocols are defined by the ZigBee Alliance. The ZigBee Alliance includes some of the leading players in the semiconductor industry, such as Invensys of the United Kingdom, Mitsubishi Electric of Japan, Motorola of the United States and Philips Semiconductor of the Netherlands. Today, the ZigBee Alliance has more than 200 enterprise members, which is why ZigBee is growing so fast. ZigBee has the following technical characteristics.

(1) Low energy consumption: ZigBee's standby mode is very power-saving, and only 2 AA batteries can support it to work for more than half a year.

(2) Low speed: ZigBee's transmission rates range from 20 to 250kbps, and it provides 250kbps (2.4GHz), 40kbps (915MHz), and 20kbps (868MHz) raw data throughput, respectively, reducing data transmission rate requirements. It also lowers the hardware barrier.

(3) Low cost: ZigBee's communication protocol is very simple, the length is only 1/10 of the Bluetooth protocol, thus reducing the requirements on the controller. The 8051's 8-bit MCU, for example, has a fully functional node chip that requires only 32 kilobytes of memory to store code, and ZigBee uses the ISM band without the need for patent fees.

(4) High capacity: ZigBee's network topology can be used in star, sheet and mesh structure. A master node manages a number of children, up to 254. In addition, each master node can also be managed by the upper layer network, and eventually can constitute a network containing 65,000 nodes, which brings great convenience for the management of a large number of nodes of WSN.

(5) High security: ZigBee stipulates three levels of security mode -- no security Settings, the use of access control list (ACL), and the use of advanced encryption standard (AES 128) symmetric password, users can set their security attributes flexibly.

(6) High reliability: ZigBee adopts the collision avoidance mechanism of CSMA/CA, and reserved special time slots for communication services requiring fixed bandwidth, so as to avoid competing conflicts when sending data; The nodes have the function of dynamic networking, and the data is transmitted in the ZigBee network by automatic routing, which ensures the flexibility and reliability of information transmission.

(7) Short delay: ZigBee's response speed is very fast. It only takes 15ms from the sleep state to the working state, 30ms for nodes to enter the network, 3S for WiFi nodes to enter the network, and 3-10s for Bluetooth nodes.

The disadvantage is that the vast majority of users in the general business field of intelligent devices do not support this protocol, so it is not used in the field of commercial indoor positioning.

UWB

UWB(Ultra Wide-Band) is a new wireless communication technology. According to the civil UWB specification formulated by the Federal Communications Commission of the United States, the operating frequency band of the UWB is 3.1 ~ 10.6GHz, and the ratio of the system bandwidth (−10dB bandwidth) to the system center frequency is greater than 20% or the system bandwidth is at least 500MHz. Compared with the traditional radio detection system, the UWB detection system does not need the carrier, and can directly use the generated narrow pulse to stimulate the antenna.

UWB positioning system mainly consists of reference mark, active mark and receiver. When UWB technology is applied in two-dimensional coordinates, TOA method is mainly used for positioning, while in three-dimensional coordinates, TDOA, AOA or the combination of the two methods are mostly used for positioning.

The main advantages of UWB are as follows: (1) Low power consumption (UWB uses ultra-short pulse, so the power spectral density of the transmitted signal is very low); (2) insensitive to channel fading; (3) strong anti-jamming ability, and will not interfere with other equipment in the same environment; ④ strong penetration performance; ⑤ When the time synchronization of transmitter and receiver is well matched, high positioning accuracy can be obtained. Positioning accuracy can reach 10cm level.

However, the development of UWB technical standards is relatively slow, so it has not been promoted to the field of consumer electronics. Common mobile intelligent devices do not support UWB protocol, and are only used in a few special industrial scenarios with high requirements. In addition, the construction of indoor positioning system based on UWB technology requires extremely high hardware cost and deployment cost.

Infrared Ray

Infrared is an electromagnetic wave with a wavelength between microwave and visible light, with a wavelength between 770nm and 1mm, located outside the red light in the spectrum. The central wavelength of the infrared spectrum used in infrared indoor positioning systems is usually 830 ~ 950nm.

Infrared indoor positioning system usually consists of two parts: infrared transmitter and infrared optical receiver. Typically, infra-red transmitters are fixed nodes in the network, while infra-red optical receivers are installed on the target to be located as mobile terminals.

Infrared indoor positioning has the advantages of high positioning accuracy, sensitive reaction and low cost of a single device. But its disadvantages are also obvious: first, because of the linear transmission of light, the infrared indoor positioning system is limited to the line-of-sight positioning; Second, the attenuation of infrared light in the air is very large, so it is only suitable for short distance transmission, which limits the application range of the system; Third, sunlight or other light sources may also interfere with it, affecting the normal transmission of infrared signals.

Visible Light

Visible light communication technology uses the high-frequency flashing signal emitted by LED light source to encode the position coordinate information of the LED emitting source. The photosensitive sensor decodes the received visible light signal and calculates the position information of the mobile device.

The advantage is that it can rely on the LED lighting already deployed in the room, and it is not affected by radio interference. The drawback is that the LED lights are required to be flicker coded, and positioning accuracy is drastically reduced due to non-line of sight communication issues.

Ultrasonic Wave

Usually there are few positioning systems that only use ultrasonic as a measurement means, often need to combine it with other ways to achieve positioning. One possible approach is to combine radio frequency and ultrasound, such as AT&T's Active Bat system and MIT's Cricket system. The hardware facilities of such schemes usually include: a number of fixed radio frequency and ultrasonic transmitters as beacon nodes; A fixed synchronization node; One or more mobile nodes equipped with radio frequency and ultrasonic receivers; An aggregation node and monitoring center. The positioning process of the system is as follows:

(1) Synchronous nodes broadcast synchronous signals through RF channels in a period of T;

(2) After receiving the synchronous signal, the beacon node postpones ΔT for a short period of time respectively, and then sends out its own position identification

The radio frequency signal and ultrasonic signal;

(3) The mobile node starts timing after receiving the synchronous signal, and then receives the ultrasonic signal from each beacon node

After recording the time difference respectively;

(4) Before the timing period is full T, the mobile node transmits the time difference data to the sink node;

(5) The sink node then sends the node signal to the monitoring center through the wired way, and the monitoring center passes the TDOA algorithm

Complete calculation and positioning.

The advantages of ultrasonic positioning are relatively high positioning accuracy and simple structure of a single device. But its defects are also very obvious: ultrasonic reflection, scattering phenomenon is very common, especially serious in the room, has a strong multipath effect; In addition, the attenuation of ultrasonic waves in the air is also very obvious, which requires laying a lot of hardware network facilities, and the system cost is very high.

Indoor microphone array positioning technology

Microphone array refers to a number of microphones arranged by a certain geometric structure. It can collect sound waves from the desired direction, while suppressing the sound of other directions and environmental noise, with a strong directional selectivity.

Microphone array positioning technology is based on array signal processing. The most important task of array signal processing is to determine the direction of arrival (DOA), and the direction characteristics of microphone array can be used in the field of location, that is, the location of sound source. At present, microphone array positioning technology can be divided into the following three categories.

1. Location technology based on time delay estimation

In this method, the distance between the sound source and each array element is estimated by obtaining the relative time delay between each node of the microphone array, and then the location of the sound source is calculated. Generalized cross-correlation function (GCC) is often used in this kind of localization method. GCC refers to the cross-correlation function between the two signals in the time domain by calculating the mutual power spectrum between the two signals, weighting it in the frequency domain to suppress the influence of noise and reflection, and then inverting it. The other is the location method based on TDOA. This method is a two-step localization method, which first estimates the time difference between the signal arriving at different microphones, and then multiplies the speed of sound to get the distance difference, and then determines the location of the sound source through the geometric relationship. The theory requires at least three independent time delay estimators, each of which corresponds to a hyperboloid (two dimensional), and the point where the three hyperbolas intersect is the location of the sound source. However, due to the influence of errors and the resolution of the system itself, it is difficult for the three curves to intersect at a point, so only one region can be obtained, and then the optimal solution can be obtained through the least square method and other algorithms.

The main disadvantages of this method are as follows: first, time delay estimation and location estimation are divided into two stages. When the processing speed of the system is slow, the location estimation in the second stage cannot meet the real-time requirements; Second, the time-delay based localization method is only suitable for mono source localization, and it is difficult to be suitable for multi-target localization.

2. Controlled beamforming based on maximum output power

This method adopts beamforming technology, the idea is to filter the sound source signal received by the microphone and then form a beam by weighted sum, and then scan in the whole space, guide the beam by searching the possible position of the sound source, and finally maximize the output power of the beam, which is the position of the sound source obtained [116]. Different beamforming methods can be used to form different algorithms, such as delayed cumulative beamforming algorithm and adaptive beamforming algorithm, which usually adopt the maximum likelihood criterion.

This kind of method has three main disadvantages: first, it needs to carry on the global search, the computation is heavy, it is difficult to carry on the real-time processing; Second, it is very sensitive to initial values and is not robust. Thirdly, the priori knowledge of the spectrum characteristics of the sound source signal is needed, which is difficult to achieve in practical application.

3. A localization technique based on high resolution spectral estimation

With the development of modern signal processing, many high-resolution spectral estimation algorithms have emerged, which can be roughly divided into three categories: The first is the super-resolution algorithm based on linear prediction, such as minimum variance spectrum estimation (MVSE), harmonic analysis (HA), the maximum entropy method (MEM), etc., this is the time domain spectrum estimation method is extended to the airspace after a series of algorithms, because this kind of algorithm is the precondition of signal source is continuous distribution in space and for stationary random process, Therefore, it greatly limits its application in the real environment; The second category is the super-resolution algorithm based on feature subspace class, such as multiple signal classification (MUSIC), rotating factor not reform (ESPRIT) and so on, this kind of algorithm based on array receiving data decomposition (e.g., singular value decomposition), it can be divided into two mutually orthogonal subspace, a signal subspace, a noise subspace, Then the spatial spectral peaks with high resolution can be found by subspace decomposition. The third category is the subspace fitting algorithm, such as maximum likelihood (ML), weighted subspace fitting (WSF), multi-dimensional MUSIC algorithm, etc. The biggest feature of this kind of algorithm is that it can still carry out effective estimation in the case of coherent source, but it has a large amount of computation and poor real-time performance.

The main disadvantage of spectrum estimation is that most algorithms are designed based on far-field narrow-band signals, but in practice, the signal received by microphone array is a wideband voice signal without any modulation, and the sound source cannot be regarded as a far-field signal in indoor environment.

Geomagnetism

Indoor positioning technology based on geomagnetism is a new positioning technology which has been gradually applied in commercial scene in recent years. The earth's magnetic field is everywhere. The geomagnetic field data of any point on the earth can be calculated according to the International Geomagnetic Reference Field Model (IGRF) published by the International Association for Geomagnetic and Upper Atmosphere Physics (IAGA) and the location longitude and latitude information.

In the reinforced concrete building structure, the geomagnetic field curve is distorted by the magnetization of iron. This distortion is only related to the relative position of the interior space, resulting in a unique geomagnetic fingerprint feature.

If the characteristics of the indoor geomagnetic fingerprint are collected in advance and the geomagnetic fingerprint database is generated, then the indoor position can be solved by the geomagnetic data signal during positioning.

Its advantage is that the geomagnetic signal does not exist non-line of sight communication problems, there is no radio wave shadow effect and multiplicity effect and other interference, as long as the indoor space structure remains roughly the same, the geomagnetic signal is relatively stable. The disadvantage is that not all indoor geomagnetic fingerprint features have strong specificity, so there will be similar features, which puts forward higher requirements for feature extraction ability and robustness of the algorithm. In general, when the specificity of local magnetic fingerprint is insufficient, the overall convergence of the algorithm can be improved by integrating other indoor positioning technologies.

SLAM

SLAM (Simultaneous Localization and Mapping) is an adaptive indoor Localization system, which is mainly used in the field of robot Localization. For example, when a robot navigates in an unknown area, it needs to have the function of determining its own position and completing mapping. SLAM enables the robot to draw a global positioning map while running in the target field. After a period of time, the robot will become more "familiar" with the environment, and the corresponding positioning accuracy will also be improved. This is a self-learning process, which can involve many fields, such as artificial intelligence, neural networks, etc.

Each data in a SLAM is used for both localization and mapping. The sources of uncertainty for SLAM can be divided into two categories: the continuous uncertainty of robot position and environmental characteristics observation; The discreteness between recognition and recognition is uncertain. Any SLAM must consider these two types of sources of uncertainty and look for possible mapping Spaces, because different configurations of data when combined produce completely different graphs.

The difficulty with SLAM is that you can't get accurate sensor measurements. However, if the measurement noises are assumed to be independent of each other and follow a Gaussian distribution, then there is an optimal solution for SLAM.

Three conditions determine the performance of SLAM: mapping quality, storage space and computation time. For SLAM, there are many ranging methods, such as active stereo imaging, static binocular or triocular imaging, and monocular imaging, etc.

In the SLAM study, stereo imaging sensors used to detect environmental data are helping to improve positioning accuracy and mapping performance. In addition, modeling of stereo imaging sensors and raw data processing is also useful for SLAM results. Kalman filter (KF) is an effective method in the field of robot localization. When the system noise satisfies the Gaussian distribution, KF uses the state cycle equation to estimate the optimal attitude of the robot. However, if the noise does not obey the Gaussian distribution, there will be errors in the localization of this method. KF can incorporate low-level multi-sensor data models. However, the environmental information generated by multi-sensor data fusion will increase the new information covariance matrix, which will increase the processing burden of SLAM system and affect the effect of localization and mapping.

Using stereo imaging system can achieve the purpose of collecting indoor three-dimensional images.

To achieve robustness, a SLAM cannot only rely on the same source of geometric measure, but also needs other information, such as sensing information outside the SLAM estimation cycle. The measurement decision of SLAM state should be independent, and only in this way can it be robust.

Conclusion: With the highest accuracy and other advantages, UWB is the most suitable method of the program.