Application of Encoding Systems

By

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Contents

Preface

A direct current motor may be equipped with encoders to transform mechanical motion into digital pulses that the integrated control electronics can understand. The basic function of the many kinds of encoders is to change the format of data so that it may be standardized, sped up, or controlled for safety. In terms of how it works, the infrared light source releases light when the shaft spins, which an optical sensor (or phototransistor) interprets and then either creates digital pulses based on whether the light goes through the disc or is stopped by the opaque sections, or vice versa. As a consequence, an information sequence is produced that enables control over variables including motion direction, turning radius, and, in certain circumstances, speed.

Robotics, tiny home appliances, and certain industrial uses that need for an angle measurement are among of its most common applications. DC motors need an encoder (which may or may not be incorporated) to establish and assure a proper shaft position because of their sophisticated position and speed control, nonlinear behavior, and reliance on the load carried.

According to their structure and purpose, encoders may be classified into many categories. The primary kinds, their functions, and key traits will be examined in the post that follows. An artificial neural network called an autoencoder is used to unsupervised learn data encodings. The goal of an autoencoder is to train the network to capture the most crucial elements of the input picture in order to learn a lower-dimensional representation (encoding) for a higher-dimensional data, often for dimensionality reduction. Data Compression, which is utilized in computer vision, computer networks, computer architecture, and many other domains, is only one example of the large variety of technologies and methods that make it possible for computer systems to solve issues. Unsupervised neural networks called autoencoders employ machine learning to do this compression for us.

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CHAPTER 1

THE ASYMMETRIC AUTO-ENCODER

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In this chapter, we will discuss the variational autoencoder, a very prominent modern probabilistic model, using a variety of concepts we have learnt in class. Latent representations may be learned using the deep learning method known as variational autoencoders (VAEs). Additionally, they have been utilised to interpolate between phrases, produce state-of-the-art semi-supervised learning outcomes, and create pictures. On VAEs, there are several online tutorials. Our presentation will likely be a little more technical than usual since we want to draw attention to links between concepts we've covered in class and demonstrate how these concepts are used in machine learning research [1]–[3].

Model deep generative

Consider the following directed latent-variable model application of the variable auto encoder p (x | z) p (z) on a facial picture (modelled by x). One may interpolate between face expressions using the learnt latent space z. To put things into perspective, think of x as an image (like a human face) and z as latent elements that explain the aspects of the face but are not visible during training. For instance, one coordinate of z may encode the gender of the face, another whether it is joyful or sad, etc.

We could also be interested in models that have a lot of layers, such as p (x z 1) p (z 1 z 2) p (z 2 z 3) p (z m 1 z m) p (z m). These can learn hierarchies of latent representations and are often referred to as deep generative models. For the sake of simplicity in this chapter, we'll suppose there is only one latent layer.

A deep generative model education

Consider that we have been given the dataset D = x 1, x 2… x n. The following inference and learning activities catch our attention:

Discovering the P's Parameters.

Computing the posterior probability p (z x) is computationally difficult. Big data: We can only deal with tiny, subsampled batches of dataset D since it cannot fit in memory. This category includes several intriguing models, of which the variational auto-encoder is one [4]–[6].

Using the conventional methods

In class, we learnt a variety of strategies that we might use for our three assignments. Let's give them a try. It is possible to train latent-variable models using the EM method. However, keep in mind that carrying out the E step requires calculating the approximative posterior p (z x), which

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we have presupposed to be intractable. By examining the full dataset, we discover the M step. However, it should be noted that there is a generalization known as online EM, which executes the M-step across mini-batches and will be too huge to store in memory.

We may utilise the mean field to conduct approximate inference. But keep in mind that each mean field step necessitates the computation of an expectation, whose time complexity grows exponentially in proportion to the size of the Markov blanket around the target variable.

As a result, we can be sure that every z variable will depend on every other z variable and that every z variable will be included in the Markov chain of some z i. As a result, the mean field will become difficult. The requisite integrals for any plausible mean-field VB method are similarly intractable, according to the authors, who refer to this. In the introduction and methodology section, they also go over the limitations of EM and sample techniques. The fact that p will include a component p (x I z 1... z k) in which all the z variables are connected provides an equal (and easier) explanation.

Using approaches that are based on sampling might be another strategy. Kingma and Welling compare the variational autoencoder to these algorithms in their landmark 2013 article that introduces the VAE, but they discover that these sampling-based techniques don't scale well to huge datasets. Additionally, methods like Metropolis-Hastings need a hand-crafted proposal distribution that may be challenging to choose from.

Automatic variation Bayes encoding

The variational auto-encoder will be one implementation of the Auto-encoding variational Bayes (AEVB) method, which can effectively handle our three inference and learning objectives. Variational inference principles form the foundation of AEVB. Remember that the goal of variational inference is to maximize the evidence lower bound (ELBO). Since x is constant, we may define q (z x) as being dependent on x. This indicates that instead of constantly selecting the same q (z), we are picking a new q (z) for every x, which will result in a better posterior approximation. Mean a field is an option, but it turns out to be too inaccurate for our needs. The coordinate descent optimization approach is oversimplified, and the assumption that q is completely factored is excessively strong.

Variational Inference with a Black Box

The AEVB algorithm's first crucial concept is a general-purpose method for optimizing q that is effective for many classes of q. (that are more complex than in the mean-field). Later, we combine this method with certain q selections. This technique, known as "black-box variational inference," initially used the phrase "black-box variational inference," with concepts from prior work like the Wake-Sleep algorithm serving as inspiration. - entails maximising the ELBO via gradient descent over (instead of e.g., using a coordinate descent algorithm like mean field). As a result, it just presupposes that q is linearly separable in its parameters.

In addition, we will concurrently do learning through gradient descent on both instead of just inference (jointly). The lower bound (and subsequently log p (x)) will continue to be pushed higher

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by optimization over, keeping ELBO close to log p (x). The EM method optimises a lower limit on the marginal probability in a manner somewhat similar to this.

The Gradient Estimator for the Scoring Function

We must calculate the gradient to do black-box variational inference. It is often impossible to take the expectation concerning q in closed form. Instead, we may sample from q and use Monte Carlo to estimate the gradient. For the gradient of p, this is simple to accomplish: by switching the gradient and the expectation, we can estimate the following formula using Monte Carlo.

It is more challenging to take the gradient concerning q, however. Keep in mind that we are unable to swap the gradient and expectation since the expectation is based on the distribution we are seeking to distinguish. The gradient is now within the expectation, which we can now assess using Monte Carlo thanks to the aforementioned identity. This is referred to as the gradient's score function estimator. Take the example that you are using Monte Carlo to estimate a quantity with an anticipated value of 1. You will be able to determine the real expectation after collecting a few samples if your results are near 1 and are 0.9, 1.1, 0.96, 1.05, etc. The expectation is still accurate, however, you will need to take a very high number of samples to determine that the real expectation is one, if you sample zero 99 times out of 100 and sample 100 once. The latter situation is referred to as high variance.

Bibliography

[1] E. J. Zaferani, M. Teshnehlab, and M. Vali, "Automatic Personality Traits Perception Using Asymmetric Auto-Encoder," IEEE Access, 2021, doi: 10.1109/ACCESS.2021.3076820.

[2] Y. Xu, Q. Huang, W. Wang, P. Foster, S. Sigtia, P. J. B. Jackson, and M. D. Plumbley, "Unsupervised Feature Learning Based on Deep Models for Environmental Audio Tagging," IEEE/ACM Trans. Audio Speech Lang. Process., 2017, doi: 10.1109/TASLP.2017.2690563.

[3] L. Hamrouni, M. L. Kherfi, O. Aiadi, and A. Benbelghit, "Plant leaves recognition based on a hierarchical one-class learning scheme with convolutional auto-encoder and siamese neural network," Symmetry (Basel)., 2021, doi: 10.3390/sym13091705.

[4] N. Ammour, "Atrial fibrillation detection with a domain adaptation neural network approach," 2018. doi: 10.1109/CSCI46756.2018.00147.

[5] C. Li, X. Qin, D. Yang, and G. Wei, "DGVAE:An End-to-end Model for Link Prediction in Directed Graphs," 2021. doi: 10.1145/3461353.3461390.

[6] K. Wang, Z. Guo, Y. Wang, X. Yuan, and C. Yang, "Common and specific deep feature representation for multimode process monitoring using a novel variable-wise weighted parallel network," Eng. Appl. Artif. Intell., 2021, doi: 10.1016/j.engappai.2021.104381.

CHAPTER 2

CLASSIFICATION OF ENCODERS

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An encoder is a kind of motion control sensor that essentially gives a control system feedback. An encoder converts a device part's rotational or linear motion into electronic signals, which are subsequently read out by the control system, such as the machine's counter or PLC. An encoder may be used to determine the precise location of a device's parts, the angle and number of rotations made by a motor shaft, as well as the circular rate or direction [1]–[3].

Encoder Types

The following are separated based on the measurement method and also the kind of output signal: incremental encoders (rotary-pulse transducers).

Relative Encoders (Rotating Encoders)

Additionally separated into rotational and linear encoders. The first two are used to quantify an object's angular location, but the third (linear) determines the item's longitudinal motion or variation. Encoders may be incremental or absolute and can be rotational or linear.

Progressive Encoder

A digital output signal is generated by an incremental encoder as the shaft rotates through a predetermined angle. The encoder's resolution is dependent on the number of signals (pulses) it receives every rotation. The ability to measure smaller angular displacements at a given resolution directly translates into increased dimension accuracy.

Absolute placement cannot be produced by an incremental encoder. This suggests that counting electrical pulses is how the shaft's location is determined. In the event of a power outage, the position value is determined from zero, or the spot where it was stopped. Due to several variables, including the lack of absolute shaft position precision, incremental encoders are easier and more cost-effective to manufacture than absolute encoders [4]–[6].

An incremental encoder has at least one "An" output signal, but often has two, the alleged "A" and "B," which are 90 degrees apart from one another. The "A" pulse is sent before the "B" pulse when the shaft is rotated anticlockwise. The "B" pulse will be sent before the "A" pulse when the shaft is rotated anticlockwise. Simply put, this is how the rotation's direction is determined. Encoders with three output signals are also available. When the disc is entirely rotated, the third signal, "Z," also known as "absolutely no" or "referral," is only created once. It may be used, for instance, to determine the referral (datum) point of a machine or equipment.

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Incremental encoders are often used to calculate speed in addition to location. The sequence of pulses may be counted to identify the position of the initial factor, and the number of pulses can be divided by the measured time interval to get the rate. Incremental encoders are divided into optical encoders and also magnetic converters based on the kind of sensor utilised in their creation.

Laser Encoder

The main component of an optical incremental encoder is a code disc that is attached to a shaft and has both transparent and opaque sections. The disc is illuminated by an LED, and the light passes through any transparent sections or stops in nontransparent sectors. The received light is converted into an electrical signal by a receiver with an optoelectronic component positioned on the disc's back. The encoder output signal type depends on the signal standard that has been selected; typically, it is an electromagnetic (rectangular) signal.

Electromagnetic Encoder

Each angular setting in a magnetic incremental encoder is represented by an electromagnetic field vector. A magnetic disc that is mounted to the encoder's shaft creates the necessary electromagnetic field. A Hall sensor is also included with the encoder. Typically, an integrated circuit serves as the form factor for such a sensor. It consists of a semiconductor-coated plate that is placed in an electromagnetic field. It is then subjected to a voltage, which forces electrons to flow in the proper direction vertically along the lines of the electromagnetic field. It is extremely simple to measure the strength of the electromagnetic field where the sensor is situated by measuring the voltage at the electrodes, which are positioned vertically to the field lines and the direction of the electrons. A Hall voltage is produced by the electromagnetic field and is then transformed into an electrical output signal.

With magnetic encoders, there is no need for a direct connection between the sensor and the rotating axis. As a result, they last longer since fewer moving components come into touch with one another. There are open encoders and built-in encoders, depending on the design. The Hall sensor itself is in the form of an integrated circuit across which a magnet coupled to the axis of a rotating item spins. The former has dust and water resistant housing, whilst the latter does not.

Ultimate Encoder

Absolute and incremental encoder designs are almost identical; the only difference is in the method of measurement. With absolute encoders, the output signal is produced in analogue form by providing the disc's positions with a unique code. It ensures that every angle the shaft is adjusted to at the output is given its unique code value. The so-called code signal is this. The disc of the absolute encoder additionally features an incremental track in addition to the additional coding for one mechanical change transparent and also opaque dashboards. This implies that the output may produce both analogue and electrical signals.

Absolute encoders can provide distinctive position data upon activation as well as immediately after a power failure. This is accomplished by checking the current location using the code signal that was previously set on the dial. This may be either a binary code or a Gray code in absolute encoders. Gray's code has the benefit of just requiring a little adjustment for neighbouring settings.

On the market, there are both single-turn and multi-turn encoders. The first one distinguishes the angular positioning only after a single complete rotation, from 0 to 360 degrees. To learn more about a larger number of turnings, a multiturn encoder must be employed. To make it feasible to save the number of completed turnings, a system of gears is often built up in the mechanical portion of the device. These gears form a relationship between various code discs.

Bibliography

[1] V. Turchenko, E. Chalmers, and A. Luczak, "A deep convolutional auto-encoder with pooling - unpooling layers in caffe," Int. J. Comput., 2019, doi: 10.47839/ijc.18.1.1270.

[2] G. Alain and Y. Bengio, "What regularized auto-encoders learn from the data-generating distribution," J. Mach. Learn. Res., 2015.

[3] K. D. Garcia, C. R. de Sá, M. Poel, T. Carvalho, J. Mendes-Moreira, J. M. P. Cardoso, A. C. P. L. F. de Carvalho, and J. N. Kok, "An ensemble of autonomous auto-encoders for human activity recognition," Neurocomputing, 2021, doi: 10.1016/j.neucom.2020.01.125.

[4] M. Kan, S. Shan, H. Chang, and X. Chen, "Stacked progressive auto-encoders (SPAE) for face recognition across poses," 2014. doi: 10.1109/CVPR.2014.243.

[5] A. Bouida, M. Beladgham, A. Bassou, and I. Benyahia, "Quality and texture analysis of biometric images compressed with second-generation wavelet transforms and SPIHT-Z encoder," Indones. J. Electr. Eng. Comput. Sci., 2020, doi: 10.11591/ijeecs.v19.i3.pp1325-1339.

[6] K. Armanious, C. Jiang, M. Fischer, T. Küstner, T. Hepp, K. Nikolaou, S. Gatidis, and B. Yang, "MedGAN: Medical image translation using GANs," Comput. Med. Imaging Graph., 2020, doi: 10.1016/j.compmedimag.2019.101684.

CHAPTER 3

OPERATING CONCEPT OF LINEAR ENCODERS

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Both linear and rotary encoders have a very similar fundamental functioning concept. When linear encoders are used, the type of the coded disc is changed to linear (range). By examining the lines drawn on a range with a measurement scale, which change positions as a machine moves, one may determine the horizontal displacement of a machine component. On the other hand, an angular encoder measures rotational motion by actually singing on a revolving disc with a range that also rotates while in motion. There are two methods to read linear and angular encoders: optically or magnetically [1]–[3].

Algorithm for a CNC machine tool's linear encoder operation

Linear and rotary encoders with high determination precision are employed in CNC machine tool production. They enable the execution of a feedback loop that instructs about the positioning of the pin and table in the machine's coordinate system [4]–[6].

Encoder process:

- A light beam passes through an aperture that has precisely positioned and shaped holes.
- The light source is exposed to the clear and darkened photoelectric elements employed on the range (tape).
- The photoelectric components provide electrical impulses that include information about the current location as well as the fields through which the light travels.

The benefit of an absolute linear encoder is that reactivation or a voltage drop in the machine does not need a new reference factor method. This indicates that the device remembers where it is about the encoder. Unlike incremental encoders, absolute encoders do not need extra reference markers.

Along with utter and total linear encoders, incremental linear encoders are also used in CNC machine tools. Rotating encoders are comparable to them in both manufacture and functioning. An example is an optical incremental linear encoder. A linear encoder has several slots (dashes) that are graduated properly. A light source, such as a light bulb or an LED, is placed behind the aperture, which changes the connection to the range.

The aperture's job is to guide the diffused light beam onto the range's previously described slits while also focusing it. The photoelectric features illuminate due to the presence of the slits, resulting in the creation of an electrical impulse. The number of slits the aperture shows (travels through) determines how many pulses are added to determine the location. To determine the offset instructions, two signals, A and B, are created and are 90 degrees apart from one another.

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Mechanical Attachments

All encoders work by exchanging an electrical output signal for mechanical motion. Encoders are quickly and simply connected to spinning machine parts via flanges, grooves, or holes.

While discussing the mechanical connections of encoders, it is important to note that when it comes to rotary encoders, we differentiate between shaft encoders, which may be mounted directly on the drive shaft using a combining, and hollow encoders, which can be inserted into the shaft at any point. In some of the developed devices, the bore and shaft diameters may be readily changed, for example, by employing reduction bushings.

Aspects of incremental encoder output signals

Incremental encoders typically output two rectangle-shaped signals with a 90° offset that may be used to detect the location and direction of an object. They are used to produce various outcomes because of their physical design. As a consequence, type outcomes make up the main categories the most popular outputs for incremental encoders are TTL and HTL. The TTL (Line Driver) outputs have excellent noise immunity and a high response frequency.

Bibliography

[1] D. Gurauskis and A. Kilikevičius, "Dynamic behaviour analysis of optical linear encoder under mechanical vibrations," Mechanika, 2020, doi: 10.5755/j01.mech.26.1.23070.

[2] Y. Shi, Q. Zhou, X. Li, K. Ni, and X. Wang, "Design and testing of a linear encoder capable of measuring absolute distance," Sensors Actuators, A Phys., 2020, doi: 10.1016/j.sna.2020.111935.

[3] D. Gurauskis, A. Kilikevičius, S. Borodinas, and A. Kasparaitis, "Analysis of geometric and thermal errors of linear encoder for real-time compensation," Sensors Actuators, A Phys., 2019, doi: 10.1016/j.sna.2019.06.055.

[4] F. Hu, X. Chen, N. Cai, Y. J. Lin, F. Zhang, and H. Wang, "Error analysis and compensation of an optical linear encoder," IET Sci. Meas. Technol., 2018, doi: 10.1049/iet-smt.2017.0230.

[5] J. M. Muyor, P. Granero-Gil, and J. Pino-Ortega, "Reliability and validity of a new accelerometer (Wimu®) system for measuring velocity during resistance exercises," Proc. Inst. Mech. Eng. Part P J. Sport. Eng. Technol., 2018, doi: 10.1177/1754337117731700.

[6] A. Ferro, P. Floría, J. Villacieros, and A. Muñoz-López, "Maximum velocity during loaded countermovement jumps obtained with an accelerometer, linear encoder and force platform: A comparison of technologies," J. Biomech., 2019, doi: 10.1016/j.jbiomech.2019.07.025.

CHAPTER 4

OPTICAL ROTARY ENCODERS

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Rotating encoders monitor the motion of motor shafts in a variety of commercial and industrial systems. Incremental encoders are often employed by ac induction motors in industrial applications where just relative position is required or cost is a consideration. In contrast, permanent-magnet brushless motors are often combined with absolute encoders in servo applications because they provide a separate binary output at each position, allowing shaft position to be precisely calculated. Encoder feedback is often employed to assure the synchronisation of the motor stator and rotor coordinates to the drive-supplied current. When the rotor magnets are in the right position range, the current is provided to the windings to maximise torque. Sites at machinedesign.com 2014 May.

Absolute rotary optical encoders intercept light beams with a disc to produce a pattern that is then decoded by electronics. For rotary encoders, form factor, degree of sturdiness, and resolution are all defined. Resolution for incremental encoders is measured in counts per turn. It is the locations per turn, represented as a multi-bit word, for absolute single-turn encoders. Positions per input-shaft turn and the number of internal gear-ratio turns are the specifications for multiturn encoders (those that track through several 360° rotations [1]–[4].

The quantity of places that must be measured determines the required resolution. For instance, a machine needs an absolute encoder with a resolution of 25,000 points if it has to measure the journey of a 25-inch lead screw in steps of 0.001 inches. However, resolution in this context is often described in terms of bits: For instance, a 12-bit encoder corresponds to the binary value 212, which is 4,096 decimals. The resolution of a 12-bit encoder is thus 4,096 points.

Unlike a resolution, accuracy relies on interactions with the application across the whole system and may be traced to the encoding disc a subcomponent we'll talk about further in detail and the difference between the real and theoretical location. For instance, a good 12 or 13-bit encoder is accurate to half a count on the least important bit. The variance of the real encoder position between succeeding identical code readings is referred to as repeatability, or the encoder's capacity to read the same location each time the shaft is in a certain position. Although there is no connection between the two, it is often four to 10 times better.

An Aside on Resolvers and Encoders

Resolvers are extremely robust electromechanical devices with an electrified rotor and twin stator windings that pick up different induced voltages depending on shaft position. These resolvers, which are technologically advanced but well-proven, report absolute positioning with an accuracy of 3 to about 50 arc-min., but they are only capable of 200:1 speed ranges and require complicated installation and circuitry. In contrast, simple-to-use encoders provide intrinsically digital signals, superior precision (usually 0.1 to 35 arc-min.), and speed ranges of more than 100,000:1. They are an acceptable component for all except the most demanding applications [5]–[7].

The most common kind of optical encoder, the rotary type, has a code disc, a light detector, and signal processor sites at machinedesign.com 2014-05-05 Machinedesign.com File Uploads Optical Quadrature Incremental Encoder. Measurement accuracy is not limited to but does reflect, the mechanical accuracy of the pattern on the code disc. The explanation is that each opaque area or "line" in a quadrature encoder generates not one, but four different reference locations. The leading and trailing edges of the line itself are represented by two points, while the leading and trailing edges as seen by a second detector are represented by two more points. Four times the resolution of the code disc is provided by this, and it also shows direction dependent on which detector answers first.

The disc travels between the LED and detector and features portions that are both opaque and transparent, interrupting the light beam sporadically. The detector records the sequence of light exposures it observes, sending that data to the processor to derive motion data.

Bibliography

[1] M. Vaiana and S. F. Muldoon, “Multilayer Brain Networks,” J. Nonlinear Sci., 2020, doi: 10.1007/s00332-017-9436-8.

[2] X. Sui, Q. Wu, J. Liu, Q. Chen, and G. Gu, “A review of optical neural networks,” IEEE Access, 2020, doi: 10.1109/ACCESS.2020.2987333.

[3] R. Damasevicius et al., “Litnet-2020: An annotated real-world network flow dataset for network intrusion detection,” Electron., 2020, doi: 10.3390/electronics9050800.

[4] E. H. Klijn, I. van Meerkerk, and J. Edelenbos, “How do network characteristics influence network managers’ choice of strategies?,” Public Money Manag., 2020, doi: 10.1080/09540962.2019.1665828.

[5] M. Sun, S. Zhao, C. Gilvary, O. Elemento, J. Zhou, and F. Wang, “Graph convolutional networks for computational drug development and discovery,” Briefings in Bioinformatics. 2020. doi: 10.1093/bib/bbz042.

[6] P. Zurn and D. S. Bassett, “Network architectures supporting learnability,” Philosophical Transactions of the Royal Society B: Biological Sciences. 2020. doi: 10.1098/rstb.2019.0323.

[7] B. Schwarz et al., “Temporal scale-dependence of plant–pollinator networks,” Oikos, 2020, doi: 10.1111/oik.07303.

CHAPTER 5

VARIABLES FOR ENCODER SUBCOMPONENTS

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As described in the following section, gearless multiturn encoder designs are also produced in optical and magnetic forms. The number of full cycles generated on one channel during one rotation of the encoder shaft is the definition of resolution, which is often overspecified. The quantity and quality of the patterns or slots on the code disc, as well as the stiffness and stability of the mechanical assembly, are factors that impact accuracy [1]–[3].

The strong plastic disc of this vector-duty encoder can endure 400 g of stress, and bigger, securely fastened bearings boost runout resistance. Resolution is 5,000 ppr, and the encoders can operate in temperatures between -40 and 100 °C, which makes them excellent for hot vector-duty motors.

The direct-read (native) resolution is determined by the number of optical disc slots. The light that may pass is reduced when there are too many lines or slots because the lines and slots must be narrower to fit on the disc. As the number of lines (or slots) increases, there is a greater chance that this light may exhibit fringing effects and crosstalk, which weaken the signal.

Over direct-read, electric interpolation improves resolution. Utilizing a voltage divider circuit to split the raw analogue signal into the necessary number of interpolation steps is a fairly typical technique for electronic interpolation. Such interpolations enable 20x resolution increases and are often a function included in encoder circuitry and visible to the motion designer.

Variables for Encoder Subcomponents

Traditional optical encoder systems use a mask between the detector and disc to boost accuracy by sharpening the edges of light pulses landing on the detectors since LED emitters and detectors are larger than disc slots. The mask also enables adjustment to discs with various resolutions, but it also raises construction costs, increases the possibility of interference, and dims light entering the detector. Many vendors provide encoders without masks to give the disc and detectors more room and increase resistance to phase error and edge jitter across channels. Better LEDs, detectors, and lenses are examples of enabling technology.

On rotary optical encoders, the code discs also known as wheels are made of etched metal, Mylar, emulsion on tempered glass, or chrome on glass. The latter provides improved edge definition, condensation resistance, and durability but is vulnerable to scratching and stress fracture. Plastic discs can withstand stress, although some of them may deform in hotter environments. Metal discs may be less accurate than glass types, but they can endure stress, heat, and chemicals.

Particulate and liquid contamination are particular dangers to encoders based on optics. When encoders are directly exposed to hot, pressured water, coolants, lubricants, and cleaning chemicals

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in outdoor and washdown applications, liquid infiltration occurs. Variations in the ambient temperature might hasten encoder failure rates as well. The pressure differential between the inside of the housing and the outside environment may cause air to be drawn into the latter during encoder cooling. The probability of failure increases when the temperature of the encoder's housing lowers, causing trapped humidity to condense within and gather dew on the code disc, printed boards, and wiring. Finally, conventional encoders may be invaded by sand, salt, tiny wood chips, or dust particles without ruggedized sealing, obstructing optical processes and lowering performance.

Magnetic Rotary Encoders

Due to their inherent toughness, magnetic encoders consistently function at extreme temperatures, shock, and vibration. Rotating magnetic encoder performance may be harmed by magnetic debris entry, but not by other pollutants. Rotary magnetic encoders are so often employed in place of optical encoders. Either a Hall effect or a strong magnetic sensor detects passive changeable reluctance or magnetised strips on a spinning code rotor, wheel, or band. Which one of the two is more appropriate for a given application depends on motor velocity and position precision [4]–[6].

Rotary magnetic encoders may be simple, low-cost devices used in high-volume applications like antilock brakes on cars, or complex devices that need to perform motion control operations like industrial automation systems and medical equipment. Incremental and absolute kinds, non-contact and bearing versions, and units where the rotating unit and encoder body are essentially independent subcomponents are among the available varieties. In essence, the majority of Hall-effect magnetic encoders track a wheel that is linked to the motor shaft and is magnetically surrounded by the north and south poles. It is typically constructed from an injection-moulded ferrite that has a pole array implanted in it.

As an example, a 7.6 mm diameter wheel with 32 poles (16 north and 16 south) is magnetised in a 15 mm encoder using a static fixture. The maximum number of poles that may be implanted is often limited by fixture size. The lowest practicable size that a fixture can support is a 32-pole motor with a pole pitch of around 0.75 mm.

Consider a typical configuration that includes a target magnet disc, three digital Hall-effect sensors on a circuit that detect commutation signals from the wheel, and they are spaced 120 degrees electrically apart. Here is a magneto resistive-based bearingless tachometer with a magnetic pulse wheel that exhibits many of the same properties as the encoders built using this technology. The primary distinction: Tachometers don't monitor location as encoders do; they only measure speed.

When the magnetic field from the revolving encoder wheel reaches a flux density sufficient to surpass a critical threshold level, Hall-effect encoders often switch with an output characterised by hysteresis. The detected field also reverts to its initial condition when its flux density falls below a lower threshold level.

This kind of procedure is used by more than only encoders of average size. Digital signal processing and field-sensing Hall components are combined in certain small single-magnet system-on-chip designs to provide simultaneous absolute, incremental, and pulse-width-modulated digital outputs. ASIC is surrounded by an array of Hall effect sensors that detect

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changes in magnetic flux and produce a voltage when the tiny, diametrically polarised magnet spins above it.

Today, however, smaller and more expensive encoders are required to have greater resolution. Encoders made of magnetoresistive material, which reduces bulk resistance by around 1.6% in the presence of a saturating magnetic field, are increasingly meeting this demand. There are two key ways that magnetoresistive sensors and Hall-effect sensors diverge. First off, compared to conventional switching fields for digital Hall sensors, the saturating field is an order of magnitude less, in the region of 0.003 to 0.005 T. Magnetoresistors are now more sensitive measurement tools as a result. Second, the 32-pole wheel provides 32 pulses per rotation, twice the resolution of earlier sensors, since the change in resistance is independent of the polarity of the magnetic field.

Bibliography

[1] A. A. Sujata and Y. S. Lalitha, "Design and performance analysis of 4-bit Nano-Processor design for low area, low power and minimum delay using 32nm FinFET technology," WSEAS Trans. Electron., 2021, doi: 10.37394/232017.2021.12.1.

[2] P. F. Noronha and M. Bhan, "Summary Generation Using Deep Learning," 2021. doi: 10.1109/ICECCT52121.2021.9616945.

[3] T. Simon and A. P. Chandrakasan, "An Ultra Low Power Adaptive Wavelet Video Encoder with Integrated Memory," IEEE J. Solid-State Circuits, 2000, doi: 10.1109/4.839917.

[4] J. Palacín and D. Martínez, "Improving the angular velocity measured with a low-cost magnetic rotary encoder attached to a brushed dc motor by compensating magnet and hall-effect sensor misalignments," Sensors, 2021, doi: 10.3390/s21144763.

[5] H. C. Wang, G. H. Yu, J. L. Cao, and L. J. Wang, "Electroless plating Co-P films for high performance magnetic rotary encoders," Sensors Actuators, A Phys., 2011, doi: 10.1016/j.sna.2010.10.024.

[6] G. Chatzipirpiridis, S. Gervasoni, C. Fischer, O. Ergeneman, E. Pellicer, B. J. Nelson, and S. Pané, "3D Printing of Thermoplastic-Bonded Soft- and Hard-Magnetic Composites: Magnetically Tuneable Architectures and Functional Devices," Adv. Intell. Syst., 2019, doi: 10.1002/aisy.201900069.

CHAPTER 6

IoT HARDWARE

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IoT software uses interfaces, embedded systems, better service, and applications to handle its two main networking and action domains. Within the IoT network, these particular and master apps are in charge of data gathering, realization, real-time analytics, and implementation and process expansion [1]–[3]. When carrying out related duties, they take use of integration with important business systems such as ordering systems, robots, scheduling, and more.

- **Data Gathering**

This programme controls data aggregation, light data security, light data filtering, and sensing. It helps sensors connect to machine-to-machine networks in real-time by using certain protocols. After then, it gathers information from various devices and disperses it in line with parameters. Additionally, it operates backwards by dispersing data between devices. Eventually, the system sends all of the data it has gathered to a centralized server. Device Integration Software that supports integration ties dependencies together all system devices to form the IoT system's physical structure. It assures that devices will cooperate and have reliable networking. Since the IoT network cannot function without these apps, they constitute the defining software technology of the IoT network. To enable communication, they control the numerous apps, protocols, and restrictions of each device.

- **Analytics in real-time**

These programmes transform data or input from numerous devices into workable actions or distinct patterns that can be examined by humans. To carry out automation-related activities or offer the data needed by the industry, they evaluate information based on a variety of settings and designs.

- **Extension of the Application and Process**

By extending the functionality of current software and systems, these applications provide a larger, more functional system. They include preconfigured devices for certain uses like granting access to particular mobile devices or engineering tools. It encourages increased output and more precise data gathering.

IoT Protocols and Technologies:

IoT mostly makes use of networking and standard protocol technologies. However, LTE-A, WiFi-Direct, NFC, low-energy Bluetooth, low-energy wireless, and low-energy radio protocols are the main IoT-enabling technologies and protocols. In contrast to a typical uniform network of common

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systems, these technologies enable the particular networking capabilities required in an IoT system [4]–[6].

- **RFID and NFC**

Near-field communication (NFC) and RFID (radio-frequency identification) provide simple, low-energy alternatives for connection bootstrapping, payments, and identity and access tokens.RFID technology uses two-way radio transmitters and receivers to recognise and follow tags attached to things.

- NFC entails communication methods for electronic gadgets, usually mobile and commonplace gadgets.
- Bluetooth Low-Energy
- This technology utilises a common technology with built-in support across platforms to satisfy the low-power, long-use requirements for IoT operation.
- Wireless Low-Energy

The IoT system's most power-intensive component is replaced by this technology. Although sensors and other components may be turned off for extended periods, wireless communication connections must always be in the listening state. Low-energy wireless not only cuts down on consumption but also makes a gadget last longer thanks to decreased use.

- **Wireless Protocols**

Radio technologies for building low-rate private area networks include ZigBee, Z-Wave, and Thread. Unlike many comparable alternatives, these technologies are low-power yet provide tremendous throughput. Small local device networks now have more strength without the usual expense.

- **LTE-A**

LTE-A, or LTE Advanced, offers a significant improvement over LTE technology by expanding coverage while simultaneously lowering latency and improving speed. With a vehicle, unmanned aerial vehicles, and other similar communication devices as its most important uses, it provides IoT with a huge power that expands its range.

We use the LDR's trait that its resistance fluctuates with light intensity in our suggested method. In our suggested system, night and day are distinguished using LDR, and after that, during the day, street lights are turned off, and at night, they have turned on automatically. If there are fewer people around the car on the street, this will be detected and the light will be turned off; if the vehicle is there, the light will be turned on.

By integrating IR proximity sensors and ZigBee wireless technology to maintain wireless contact between the lights and the control terminal, street lights are independently monitored and managed based on light intensity for the creation of dynamic control flow-based statistics. Additionally, it makes use of a variety of parts, including LEDs, photodiodes, timers, power transistors, and data

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on the volume of traffic. The suggested method automatically adjusts the street lights according to brightness, dimness, and light intensity.

Seasonal changes may also be used to manage and monitor the street lights. Additionally, it has a "time cut-out feature" and an "automatic control pattern" for increasing energy saving. "PIC microcontroller" technology was used to carry out this project. The project is built utilising "ZigBee modules," which are used to control and monitor the light as well as find and fix broken bulbs. The chapter highlights an adaptive lighting system that makes decisions about whether to turn on, off, or dim the lights depending on the presence of vehicles, bicycles, and pedestrians. The PIR motion sensor is the sensor that is utilised in the project to detect movement in everything around it.

Bibliography

[1] Y. Zhang, S. Shao, M. Ji, J. Qiu, Z. Tian, X. Du, and M. Guizani, "An automated refactoring approach to improve IoT software quality," Appl. Sci., 2020, doi: 10.3390/app10010413.

[2] D. Valente da Silva, B. Pedraça de Souza, T. Guidini Goncalves, and G. Horta Travassos, "Requirements Engineering Technology for the IoT Software Systems," J. Softw. Eng. Res. Dev., 2021, doi: 10.5753/jserd.2021.1892.

[3] O. Leiba, R. Bitton, Y. Yitzchak, A. Nadler, D. Kashi, and A. Shabtai, "IoTPatchPool: Incentivized delivery network of IoT software updates based on proofs-of-distribution," Pervasive Mob. Comput., 2019, doi: 10.1016/j.pmcj.2019.04.010.

[4] D. D. Olatinwo, A. M. Abu-Mahfouz, and G. P. Hancke, "Towards achieving efficient MAC protocols for WBAN-enabled IoT technology: a review," Eurasip Journal on Wireless Communications and Networking. 2021. doi: 10.1186/s13638-021-01919-1.

[5] D. Kamboj, S. Sharma, and S. Kumar, "A review on IoT: Protocols, architecture, technologies, application and research challenges," 2020. doi: 10.1109/Confluence47617.2020.9058228.

[6] S. Sinche, D. Raposo, N. Armando, A. Rodrigues, F. Boavida, V. Pereira, and J. S. Silva, "A Survey of IoT Management Protocols and Frameworks," IEEE Commun. Surv. Tutorials, 2020, doi: 10.1109/COMST.2019.2943087.

CHAPTER 7

LIGHT EMITTING DIODE (LED)

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Streetlights are mostly responsible for a city's highest expenditure. Municipal trash may be reduced by 50–70% with the help of a smart street light. The project's major uses are to monitor crimes occurring on the road using the panic button and to combat energy waste. The light will automatically turn off if sunshine is detected, and the same data can be retrieved over the internet and turned ON/OFF using an IoT device. The street light (ON/OFF Status) may be viewed on the internet at any time and from any location using a real-time system. A microcontroller, sensor, and street light controller are put on the pole of the street light, and the controller is the basis for communication between the street lights [1]–[4].

The LED street lights are managed by the controller. The sensor detects sunlight and transmits that information to the microcontroller, which then takes appropriate action following the circumstances. Here, manual mode operation is avoided, and everything is automated. The control system will be set up to turn on and off the lights at the appropriate times following the requirements. The device includes a camera to record everything that happens on the street as strangers drive by. The camera's video recordings are kept on a different server [5]–[8].

A panic button that may be pushed by the individual is supplied at an accessible height in case an emergency scenario, such as theft or harassment, occurs. In response, the current video recording is immediately transferred to a cloud account, along with an alarm sound to the specific police station in the area. A cloud-accessible account is given to each police station. The major goals of this system are to guarantee energy efficiency and safety.

- One of a city's major costs is its street lights.
- The expense is so great that all of the sodium vapor lamps use more energy.
- The money spent on this street light may be used toward other aspects of national development.
- Currently, a manual system is in a place where the light is manually turned on and off at certain times of day, such as in the evening and morning. As a result, there is significant energy loss between ON and OFF.
- Street lights have manual ON/OFF switches.
- Greater energy use as a result of the sodium vapor lights.
- Expensive since the light is designed to remain on all night;
- Demands more manpower;
- Requires routine inspection.
- Benefits of the proposed system include:
- Automated ON/OFF Street light switching.

- Because LEDs use more energy than sodium vapor lights, the cost was dramatically decreased.
- Light pollution is decreased, as well as CO_2 emissions.

There is no longer any need for human labour in communication. Currently, there is no structure in place to protect the populace, but ours creates a first step.

MSP430 MICROCONTROLLER

The MSP430 series of microcontrollers is a mixed-signal family. The MSP430 is a low-cost, especially low-power consumption embedded application processor built on a 16-bit CPU. Embedded devices with minimal power requirements may utilise the MSP430. The ideal answer for a variety of low-power and portable applications is offered by TI's MSP430 16-bit microcontroller platform of ultra-low-power RISC mixed-signal microprocessors. For the MSP430 16-bit MCU, TI offers comprehensive design help in the form of technical publications, instruction, tools, and software.

LDR SENSOR

A device whose resistivity factor depends on electromagnetic radiation is known as a Light Dependent Resistor (LDR), sometimes known as a photoresistor. As a result, they are comparable to human eyes in that they are light-sensitive sensors. Other names for them include photoconductors, conductive cells, and just plain old photocells. They are constructed of highly resistant semiconductor materials. An LDR operates according to the idea of photoconductivity. An optical phenomenon known as photoconductivity occurs when light is absorbed by a substance, reducing the medium's conductivity.

A panic alarm is a technological tool created to help inform someone in an emergency when there is a danger to people or property. These buttons may be linked to a monitoring station, a local alarm system, or a bell or siren that can be heard. The alarm may be used to call in local security, police, or emergency services for aid in an emergency. Some systems can also turn on closed-circuit television to capture the incident or analyses it. When pushed, many panic alarm buttons lock on and need a key to be reset.

Bibliography

[1] X. Zhang, Z. Bian, X. Yuan, X. Chen, and C. Lu, "A review on the effects of light-emitting diode (LED) light on the nutrients of sprouts and microgreens," Trends in Food Science and Technology. 2020. doi: 10.1016/j.tifs.2020.02.031.

[2] N. D. Nhat, D. T. Tien, T. Van Dan, N. D. Quynh Tram, N. Q. Lich, H. D. Phuc, and N. N. Phuoc, "The effectiveness of light emitting diode (LED) lamps in the offshore purse seine fishery in Vietnam," Aquac. Fish., 2022, doi: 10.1016/j.aaf.2022.01.005.

[3] L. Du, A. Jaya Prasad, M. Gänzle, and M. S. Roopesh, "Inactivation of Salmonella spp. in wheat flour by 395 nm pulsed light emitting diode (LED) treatment and the related functional and structural changes of gluten," Food Res. Int., 2020, doi: 10.1016/j.foodres.2019.108716.

[4] W. Gao, Z. Sun, Y. Wu, J. Song, T. Tao, F. Chen, Y. Zhang, and H. Cao, “Criticality assessment of metal resources for light-emitting diode (LED) production – A case study in China,” Clean. Eng. Technol., 2022, doi: 10.1016/j.clet.2021.100380.

[5] V. K. S. Hsiao, T. Y. Cheng, C. F. Chen, H. Shiu, Y. J. Yu, C. F. Tsai, P. C. Lai, M. C. Tsai, C. C. Yang, H. Y. Chien, K. F. Chen, and Y. P. Tsai, “Optimized LED-integrated agricultural facilities for adjusting the growth of water bamboo (Zizania latifolia),” Appl. Sci., 2020, doi: 10.3390/app10041330.

[6] T. Purushothaman and K. Irfana Mol, “A Critical Review on Antimicrobial Photodynamic Inactivation Using Light Emitting Diode (LED),” Shanlax Int. J. Arts, Sci. Humanit., 2021, doi: 10.34293/sijash.v8i3.3476.

[7] J. Asheim, E. V. Kvittingen, L. Kvittingen, and R. Verley, “A simple, small-scale lego colorimeter with a light-emitting diode (LED) used as detector,” J. Chem. Educ., 2014, doi: 10.1021/ed400838n.

[8] S. Mohezar, A. Sulaiman, M. Nazri, and S. Omar, “Sustaining innovative capabilities of light emitting diode (Led) manufacturers through dynamic entrepreneurship,” Entrep. Sustain. Issues, 2020, doi: 10.9770/jesi.2020.8.1(73).

CHAPTER 8

BASICS OF IMAGE ENHANCEMENT

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An image is a column- and row-organized array, or matrix, of square pixels (picture components). An image is a 2D function, f(x, y), where x and y are spatial coordinates and the amplitude of any pair of these variables is referred to as the picture's intensity or grey level [1]–[4].

Images' Types

The simplest forms of pictures are termed binary images since they only accept discrete values of 0 or 1. White is represented by 0, and black by 1. When just the contour of the picture is needed, these images are employed in computer vision.

Since grey-scale photographs only depict the brightness of a single colour, they are sometimes referred to as monochrome images. This sort of picture has just 8 bytes and 256 (0–255) brightness levels. There are several brightness levels between 0 and 255, where 255 is white and 0 is black coloured pictures Usually consist of 3 bands, each with 8 bytes of intensity: red, green, and blue. It is a 24-bit coloured picture, therefore the varied intensity levels in each band can represent the whole coloured image.

Image Processing

Images may be improved or have relevant information extracted from them using techniques for image processing, which include converting real-time objects or images into digital picture form.

Image Processing Techniques

Image representation, image pre-processing, image enhancement, image restoration, image analysis, image segmentation, and image data compression are some of the techniques used to handle images [5]–[7].

Image Augmentation

Picture processing is done with the primary goal of making the output image better than the original image. Therefore, this method boosts and improves the image's quality. Enhancing photos aesthetically by drawing attention to intriguing elements.

In image processing applications including digital photography, medical image analysis, remote sensing, LCD display processing, and scientific visualisation, enhancement is essential. Picture enhancement is a method that eliminates artefacts, decreases image noise, and preserves features. Certain picture aspects are amplified for analysis, diagnosis, and presentation.

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Image Negative, Log Transformation, Grey Level Slicing, Contrast Stretching, Bit Plane Slicing, and Power Law Transformation are some of the existing techniques for image enhancement. Photo Negative the negative transformation produces the negative of an image with grey levels between.

$S = L - 1 - r$

This is the input grey level, r. output grey level is S.

When the black parts of an image are larger, this form of processing is useful for highlighting white or grey detail that is contained in the dark levels. Transformation of Logs Log transformation is used to produce the log transformation of a picture with grey levels between [0, L 1].

S is equal to C log(1r)(1.2), where C is a constant.

In the input picture, this transformation converts a small range of low grey-level values into a larger range of output levels. This transformation is used to compress the upper-level values while expanding the values of the dark pixels in a picture. Transformation of the power law transformation is used to produce the power law transformation of a picture with grey levels between [0, L 1].

S = (1.3) (1.3)

THE CONSTANTS C ANDARE USED:

A small range of dark input values is translated into a larger range of output values via power law curves with fractional values. Images are captured, printed, and displayed by devices in a power-law response. Stretching Contrasting The dynamic range of the grey levels in the picture is expanded using this technique. Poor lighting, a lack of dynamic range in the image sensor, and incorrect lens aperture selection during picture capture may all lead to low-contrast photographs.

Slices at a Gray Level the main goal is to display a certain spectrum of grey levels. Display a high value for each grayscale within the interest range and a low value for each additional grayscale: make a binary image. Brighten the required grayscale range while preserving the backdrop and grayscale tonalities. Sliced Bit Plane a picture is made up of eight 1-bit planes since each pixel is represented by 8 bits. Analyzing the relative roles that each bit in a digital picture plays is important for figuring out if the amount of bits chosen to quantize each pixel is enough. This analysis may be done by dividing the image into its bit planes. Image compression may benefit from this kind of breakdown. In the direct approach of enhancing contrast, a contrast measure is first created, and a mapping function modifies it to produce the pixel value of the improved picture. For the contrast measure modification, several mapping functions, including the square root function and the exponential function, have been presented. These functions, however, often exhibit noise and digitization effects and do not provide sufficient contrast enhancement outcomes. They are also difficult to execute from a computational perspective. The polynomial function offers extremely excellent contrast enhancement and is ready for implementation on digital computers.

Bibliography

[1] Q. Jiang, Y. Zhang, F. Bao, X. Zhao, C. Zhang, and P. Liu, “Two-step domain adaptation

for underwater image enhancement," Pattern Recognit., 2022, doi: 10.1016/j.patcog.2021.108324.

[2] C. Li, C. Guo, W. Ren, R. Cong, J. Hou, S. Kwong, and D. Tao, "An Underwater Image Enhancement Benchmark Dataset and beyond," IEEE Trans. Image Process., 2020, doi: 10.1109/TIP.2019.2955241.

[3] W. Wang, X. Wu, X. Yuan, and Z. Gao, "An Experiment-Based Review of Low-Light Image Enhancement Methods," IEEE Access. 2020. doi: 10.1109/ACCESS.2020.2992749.

[4] R. Ablin, C. H. Sulochana, and G. Prabin, "An investigation in satellite images based on image enhancement techniques," European Journal of Remote Sensing. 2020. doi: 10.1080/22797254.2019.1673216.

[5] S. Van Der Walt, J. L. Schönberger, J. Nunez-Iglesias, F. Boulogne, J. D. Warner, N. Yager, E. Gouillart, and T. Yu, "Scikit-image: Image processing in python," PeerJ, 2014, doi: 10.7717/peerj.453.

[6] A. Khan, A. S. Qureshi, N. Wahab, M. Hussain, and M. Y. Hamza, "A recent survey on the applications of genetic programming in image processing," Comput. Intell., 2021, doi: 10.1111/coin.12459.

[7] R. A. Abumalloh, M. Nilashi, M. Yousoof Ismail, A. Alhargan, A. Alghamdi, A. O. Alzahrani, L. Saraireh, R. Osman, and S. Asadi, "Medical image processing and COVID-19: A literature review and bibliometric analysis," Journal of Infection and Public Health. 2022. doi: 10.1016/j.jiph.2021.11.013.

CHAPTER 9

IMAGE FUSION

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Signal processing challenges including the requirements for storage, the duration of calculations, and the availability of resources are sometimes compounded worse by enormous amounts of data. a lack of sensing applications, uneven decision-making, and no standardized approach for evaluating instruments from multiple manufacturers. It is sensible to merge different multi-dimensional information into one condensed representation that retains necessary information and is of greater quality than any of the inputs as a result. For a greater collaboration of opposing but underlying infrastructure, features from various sensors should supplement one another. This should make the same purpose of the picture-tracking solution evident [1].

The definition of the image conversion process is the collection of the entire crucial data from several photos and their inclusion into fewer images, commonly only one. This one picture has all the pertinent information and is more accurate and informative than just about any image from a single source. Image fusion strives to produce pictures that are more acceptable and intuitive for both humans and machines, in addition to decreasing the quantity of data. In contrast to previous methods, pixel-level image combination directly incorporates the underlying data from the source photos, providing a fused image that is much more informative for human perception and artificial intelligence algorithms. Many solutions that need the interpretation of two or more images of a circumstance have benefited from image fusion. For instance, in remote sensing data, fusing a low-resolution panchromatic (PAN) picture with a high-definition panchromatic (MS) image results in a fused image with a broader geographic resolution that incorporates the spectral information of the high dynamic range image. In image processing applications, images from many disciplines may be combined to generate a more trustworthy and precise medical representation [2].

The detection quality of the picture modality is strengthened by fusing medical images of several sensors, which may help the treatment services. For night vision in remote sensing applications, image fusion may gather this information spanning the entire electromagnetic spectrum, including that of visible and infrared bands. Identification of different objects, their users, and object-user interactions are all components of surveillance. Humans connect with random products in real life in a broad range of ways and patterns. In the last two decades, the number of publications in this area has increased tremendously. In response to practical needs, academicians have been quite active in recommending more accurate visual fusion strategies [2], [3].

This rise in research in the image fusion field can be narrowed down to three major factors:

- A rise in the desire for affordable, high-performing imaging technologies. Image fusion, which integrates images taken with types of sensors or camera settings, has emerged as a successful remedy for this issue. Limiting factors may prevent the creation of instruments with greater quality or specialist characteristics.

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- Signal analysis and signal processing principles and practice. There are several powerful image processing techniques, such as sparse presentation, which deals with sparse solutions for multiple linear regression systems.
- Methods for identifying these workarounds and utilizing theming implementations have been commonly adopted in image processing, signal processing, machine learning, medical imaging, and other fields. Multi-scale decomposition methodologies, such as pyramidal image biodegradation, also find extensive use in these domains.
- They are implemented utilizing cascaded filter banks, where the parametric equalizer and high pass filters adhere to certain requirements. They have recently been made obtainable, offering opportunities to considerably enhance image fusion effectiveness.
- The growing number and complexity of complementing images captured across multiple applications. For instance, more observatories are collecting remote sensing images of the witnessed scene for use in remote sensing techniques.
- The situation is the same in other industries, such as medical imaging. To adequately use these complementary photographs, several picture fusion techniques have been devised. Using a systematic approach, the field will be broken down into four main family members of pixel-wise image fusion approaches in this work [4].

These qualities a good fusion algorithm needs to have:

- The majority of the relevant information from either the input photographs need to be retained in the amalgamated image.
- There are no visual abnormalities produced by spontaneous fission that may divert a conventional viewer.
- The elements in the system have to be resistant to imperfect conditions like noise and misregistration [5].

There are two broad categories for the objective fusion evaluation methods now in use:

- Metrics for independent evaluation that call for a given image.
- Metrics for independent evaluation that don't need a benchmark picture [6].

Bibliography

[1] J. Ma, Y. Ma, and C. Li, “Infrared and visible image fusion methods and applications: A survey,” Inf. Fusion, 2019, doi: 10.1016/j.inffus.2018.02.004.

[2] H. Zhang, H. Xu, X. Tian, J. Jiang, and J. Ma, “Image fusion meets deep learning: A survey and perspective,” Information Fusion. 2021. doi: 10.1016/j.inffus.2021.06.008.

[3] Y. Liu, X. Chen, H. Peng, and Z. Wang, “Multi-focus image fusion with a deep convolutional neural network,” Inf. Fusion, 2017, doi: 10.1016/j.inffus.2016.12.001.

[4] Y. Liu, L. Wang, J. Cheng, C. Li, and X. Chen, “Multi-focus image fusion: A Survey of the state of the art,” Inf. Fusion, 2020, doi: 10.1016/j.inffus.2020.06.013.

[5] S. Li, X. Kang, L. Fang, J. Hu, and H. Yin, “Pixel-level image fusion: A survey of the state of the art,” Inf. Fusion, 2017, doi: 10.1016/j.inffus.2016.05.004.

[6] B. Meher, S. Agrawal, R. Panda, and A. Abraham, “A survey on region based image fusion methods,” Inf. Fusion, 2019, doi: 10.1016/j.inffus.2018.07.010.

CHAPTER 10

DISCRETE WAVELET TRANSFORM (DWT)

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Wavelet translations are linear transforms featuring wavelets as their basic functions. Wavelets exploited in image fusion go under a plethora of categorizations, including orthogonal, bi-orthogonal, as well as others. It takes a lot of time and effort to calculate wavelet coefficients at every feasible scale, and it produces a lot of data. Calculating wavelet coefficients is efficient and precise when scales and locations are often referred to as dyadic scales and locations, this set is based on powers of two. This outcome is acquired via the discrete wavelet transform (DWT). The 1D sub-band deconstruction and the 2D sub band disintegration are almost identical. Performing 1D sub band deconstruction twice once in one direction is horizontal and once in the orthogonal, which is a vertical general area of the process. [1].

For instance, the LLi and LHi sub bands are constructed by further degrading the low-pass sub bands (Li) formed in the horizontal direction in the vertical direction. HLi and HHi are supplementary sub bands from the inside of the high pass sub band (Hi). After the first transform, the picture might be further decomposed by using the 2-D sub band decomposed on the active LLi sub band. This adaptive maturation results in a number of "transform stages." In Figure 1, the first level of modification delivers LH1, HL1, and HH1 as well as LL1, which at the second level has been separated into LH2, HL2, HH2, and LL2; the third level transform uses the data from LL2. The horizontal, vertical, and diagonal remnant information of the original system is represented by the low-pass subband LLi, and the horizontal, vertical, and diagonal residual information of the original image is expressed by the high-pass sub bands LHi, HLi, and HHi, respectfully.

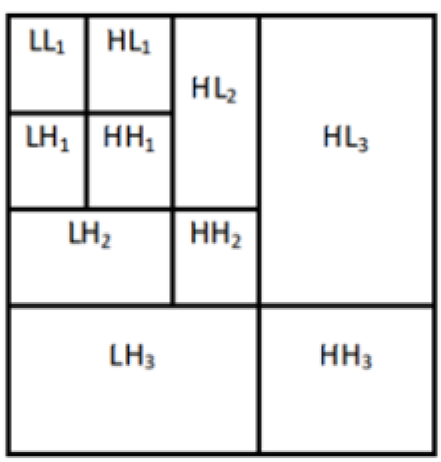

Figure 1: Illustrated the Sub band Labelling Scheme for a Three Level Transform [2]**.**

The one-dimensional wavelet transform is conducted first along the rows, then along the columns, resulting in four sub bands: low-resolution, horizontal, vertical, and diagonal. This provides a two-dimensional wavelet transform. The vertical sub band is the result of vertical edges produced by a horizontal high-pass filter. The low-resolution sub band may have the wavelet decomposition performed again at each level to further relate the picture. The image decomposition is shown in Figure 2, with the level and sub band protocols defined. A low-resolution sub band is included in the final arrangement. In addition to the different transform levels, the original picture data is also referred to as level 0 [3]. When a user demands zero levels of transformation, the processing progresses in a manner that corresponds with the original picture data (level 0), which is seen as a bandpass filter band.

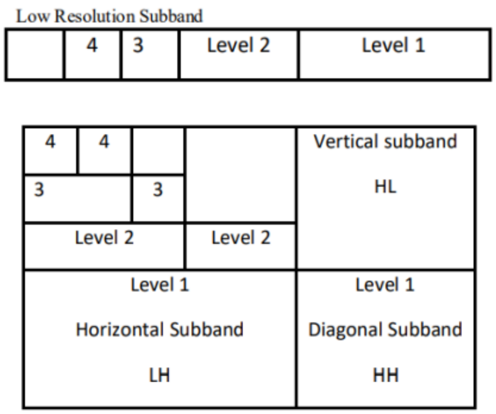

Figure 2: Illustrated the Image Decomposition using Wavelets [4]**.**

After performing a wavelet decomposition on every source image, a collection of fusion rules is employed to create a fusion decision map. The fused wavelet coefficients map may indeed be created using the fusion decision map and the wavelet coefficients of the underlying pictures. To create the fused photograph, the inverse wavelet transform is instead employed. We can see from the diagram above that the fusion rules are highly crucial during the fusion process [5], [6].

- DWT is used at a certain level to deconstruct the source photographs into useful approximation parameters during the wavelet-based image fusion process. A fusion rule is implemented to merge the coefficients, and after that, the inverse wavelet decomposition is used to result in the final picture.
- This method minimizes the spectral falsification in the ensuing fused image by constructing a good signal-to-noise ratio.

Advantages of DWT

- It provides good resolution both in the time domain and frequency domain.
- Simple and easy to understand and implement.

Disadvantages of DWT

- Some noise may be introduced in the fused image.
- Low accuracy for curved edges [7].

Bibliography

[1] Y. Liu, L. Guan, C. Hou, H. Han, Z. Liu, Y. Sun, and M. Zheng, "Wind power short-term prediction based on LSTM and discrete wavelet transform," Appl. Sci., 2019, doi: 10.3390/app9061108.

[2] A. al-Qerem, F. Kharbat, S. Nashwan, S. Ashraf, and khairi blaou, "General model for best feature extraction of EEG using discrete wavelet transform wavelet family and differential evolution," Int. J. Distrib. Sens. Networks, 2020, doi: 10.1177/1550147720911009.

[3] J. Too, A. R. Abdullah, and N. M. Saad, "Classification of Hand movements based on discrete wavelet transform and enhanced feature extraction," Int. J. Adv. Comput. Sci. Appl., 2019, doi: 10.14569/ijacsa.2019.0100612.

[4] E. B. Candrasari, L. Novamizanti, and S. Aulia, "Hand gesture recognition using discrete wavelet transform and hidden Markov models," Telkomnika (Telecommunication Comput. Electron. Control., 2020, doi: 10.12928/TELKOMNIKA.V18I5.13725.

[5] J. Zhou, Z. Cao, X. Dong, and K. K. R. Choo, "Efficient Privacy-Preserving Outsourced Discrete Wavelet Transform in the Encrypted Domain," IEEE Trans. Cloud Comput., 2022, doi: 10.1109/TCC.2019.2948012.

[6] H. Ocak, "Automatic detection of epileptic seizures in EEG using discrete wavelet transform and approximate entropy," Expert Syst. Appl., 2009, doi: 10.1016/j.eswa.2007.12.065.

[7] M. B. Priatama, L. Novamizanti, S. Aulia, and E. B. Candrasari, "Hand gesture recognition using discrete wavelet transform and convolutional neural network," Bull. Electr. Eng. Informatics, 2020, doi: 10.11591/eei.v9i3.1977.

CHAPTER 11

DC MOTOR

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A DC motor is a kind of rotating electrical device that transforms electrical energy from direct current into mechanical energy. The driver circuit's inputs determine how the DC motor operates. Any group of rotating electric motors that use direct current (DC) electricity to create mechanical energy is referred to as a DC motor. The most prevalent kinds depend on the forces created by induced magnetic fields brought on by current flowing through the coil. For a portion of the motor's current to sometimes shift direction, almost all kinds of DC motors contain an internal mechanism that is either electromechanical or electronic [1], [2].

Due to their ability to be supplied by existing direct-current lighting power distribution networks, DC motors were the first kind of motors that were extensively employed. A DC motor's speed may be varied across a large range by varying the supply voltage or the amount of current flowing through its field windings. Appliances, toys, but also tools all employ small DC motors. Either direct current or alternating current may be used to power the universal motor, a small, light brush motor used in portable power equipment and appliances. Larger DC motors are being employed for steel rolling mill drives, elevator as well as hoist propulsion, or electric vehicle propulsion. AC motors may now be used in many applications in place of DC motors thanks to the development of power electronics [3], [4].

SOIL MOISTURE SENSOR:

a soil moisture sensor that calculates the volumetric water content of the soil Soil moisture sensors measure the volumetric water content indirectly by using some other property of the soil, including such electrical resistance, dielectric constant, or interaction with neutrons as a proxy for the moisture content, because the direct gravimetric measurement of free soil moisture requires removing, drying, and weighting of a sample. It is necessary to calibrate the relationship between the measured property and soil moisture since it may change based on the environment, including the soil type, temperature, and electric conductivity [5]. The soil moisture has an impact on the reflected microwave radiation, which is employed for remote sensing in agriculture and hydrology. Farmers and gardeners may both employ portable probing tools. Sensors that assess the volumetric water content are often referred to as soil moisture sensors. Water potential is a different kind of soil moisture attribute that is measured by another class of sensors [6].

The volumetric water content of the soil is determined using the soil moisture sensor. This makes it the perfect place to conduct experiments for classes in biology, horticulture, botany, agricultural science, soil science, and environmental science. Using the soil moisture sensor, you can:

- Calculate the amount of moisture that evaporates and that plants absorb over time.

- Determine the ideal soil moisture levels for different plant types.
- Keep an eye on the soil moisture level to regulate water in greenhouses.
- Improve your investigations using bottle biology

ELECTROMECHANICAL RELAYS:

- Similar to a switch, a relay can only be opened or closed.
- When the switch is open, no electricity is delivered to the load attached to the relay since the circuit is open and the switch is not closed.
- When a relay is shut off, the circuit is complete, current flows through the relay, and the load receives electricity.
- A relay is opened and closed using an electromagnet.
- The electromagnet causes the contacts in the relay to link and transmit current through the relay when the coil controlling the electromagnet is given a voltage.
- COM- Common pin.
- NC stands for Normally Closed, which means that when INT1 is set low, NC is linked to COM, and when INT1 is set high, NC is not.

ESP8266 INTERFACING RELAY

- The relay has four pins: VCC, GND, IN1, and IN2. External devices are driven by IN1, and IN2.
- Vcc is linked to the ESP8266 wifi module's Vcc pin to power the relay.
- The ESP8266 wifi module's GND pin is wired to the GND pin of the GND pin.
- To power the water pump, IN1 is linked to the ESP8266 wifi module's D6 pin.
- The water pump activates and pumps the water whenever the ESP8266's D6 pin is high.

SOIL MOISTURE SENSOR INTERFACING WITH ESP8266WIFI MODULE

- The ESP8266 wifi module cannot directly communicate with a soil moisture sensor. It is linked to the comparator LM293 device.
- The LM293 Comparator has 4 pins, including VCC, GND, D0, and A0.
- The comparator's VCC pin is wired to the ESP8266 wifi module's VCC.
- The comparator's GND pin is linked to the ESP8266 wifi module's GND pin.
- To use the digital output, connect the comparator's D0 pin to the ESP8266 wifi module's D4 pin.

Bibliography

[1] M. S. Amiri, M. F. Ibrahim, and R. Ramli, “Optimal parameter estimation for a DC motor using genetic algorithm,” Int. J. Power Electron. Drive Syst., 2020, doi: 10.11591/ijpeds.v11.i2.pp1047-1054.

[2] S. S. Sami, Z. A. Obaid, M. T. Muhssin, and A. N. Hussain, “Detailed modelling and simulation of different dc motor types for research and educational purposes,” Int. J. Power Electron. Drive Syst., 2021, doi: 10.11591/IJPEDS.V12.I2.PP703-714.

[3] R. T. Yunardi, D. Arifianto, F. Bachtiar, and J. I. Prananingrum, "Holonomic implementation of three wheels omnidirectional mobile robot using DC motors," J. Robot. Control, 2021, doi: 10.18196/jrc.2254.

[4] M. Saad, A. H. Amhedb, and M. Al Sharqawi, "Real time DC motor position control using PID controller in LabVIEW," J. Robot. Control, 2021, doi: 10.18196/jrc.25104.

[5] H. E. A. Ibrahim, F. N. Hassan, and A. O. Shomer, "Optimal PID control of a brushless DC motor using PSO and BF techniques," Ain Shams Eng. J., 2014, doi: 10.1016/j.asej.2013.09.013.

[6] T. P. Cabré, A. S. Vela, M. T. Ribes, J. M. Blanc, J. R. Pablo, and F. C. Sancho, "Didactic platform for DC motor speed and position control in Z-plane," ISA Trans., 2021, doi: 10.1016/j.isatra.2021.02.020.

CHAPTER 12

APPLICATION OF IoT SOFTWARE

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IoT software uses platforms, partner systems, embedded systems, and middleware to handle its two main networking or action domains. Within the IoT network, these particular and master apps are in charge of data gathering, real-time analytics, device integration, or application and process expansion. When carrying out related duties, they take use of integration with important business systems such as ordering systems, robots, scheduling, and more. The majority of Internet of Things (IoT) devices only have little computational power. IoT software makes it easier for such devices to transport and interpret the data they gather so they may execute their action or function remotely. Additionally, the software handles the crucial tasks of automating and controlling smart devices for users, enabling data access for just-in-time information, and enhancing sensor data collecting [1]–[3].

This program controls data aggregation, light data filtering, light data security, and sensing. It helps sensors connect to machine-to-machine networks in real-time by using certain protocols. After then, it gathers information from various devices and disperses it in line with parameters. Additionally, it operates backwards by dispersing data between devices. Eventually, the system sends all of the data it has gathered to a centralized server. Sensors don't always communicate immediately relevant information. Processing data, using formulae, producing aggregations, and figuring averages are often required. An interface for specifying the activities that must be carried out on the data is provided by the IoT Factory software platform [4]–[6]. The creation of warnings based on sensor data is crucial. These notifications may be seen on the web application, or they can be sent through email, SMS, or mobile push. Real-time, or compiled and broadcast at a specific frequency

DEVICE INTEGRATION

Device Binding Software that supports device binding ties (dependent connections) all system devices together to form the IoT system's physical structure. It makes sure that gadgets are cooperating and networking steadily. Since the IoT network cannot function without these apps, they constitute the defining software technology of the IoT network. To enable communication, they control the numerous apps, protocols, and restrictions of each device.

ANALYTICS IN REAL TIME

These programs transform data or input from numerous devices into workable actions or distinct patterns that can be examined by humans. To carry out automation-related operations or offer the data needed by the industry, they evaluate information based on a variety of settings and designs.

APPLICATION AND EXTENSION OF THE PROCESS

By extending the functionality of current software and systems, these applications provide a larger, more functional system. They include preconfigured devices for certain uses like granting access to particular mobile devices but rather engineering tools. It encourages increased output and more precise data collecting.

IOT PROTOCOLS AND TECHNOLOGIES:

IoT mostly makes use of networking and standard protocol technologies. However, WiFi-Direct, LTE-A, NFC, low-energy wireless, low-energy Bluetooth, and low-energy radio protocols are the main IoT-enabling technologies or protocols. In contrast to a typical uniform network of common systems, these technologies enable the particular networking capabilities required in an IoT system.

RFID and NFC

- Near-field communication (NFC) and RFID (radio-frequency identification) provide simple, low-energy alternatives for connection bootstrapping, payments, and identity and access tokens.
- RFID uses 2-way radio transmitters and receivers to locate and follow tags attached to items.
- NFC is made up of electronic device communication protocols, often for mobile smartphones and conventional devices.

BLUETOOTH LOW-ENERGY

This technology utilizes a common technology with built-in support across platforms to satisfy the low-power, long-use requirements of IoT operation.

WIRELESS LOW-ENERGY

The IoT system's most power-hungry component is replaced by this technology. Although sensors and other components may be turned off for extended periods, wireless communication connections must always be in the listening state. Low-energy wireless not only cuts down on consumption but also makes a gadget last longer thanks to decreased use.

WIRELESS PROTOCOLS

Radio technologies for building low-rate private area networks include ZigBee, Z-Wave, and Thread. In contrast to many comparable solutions, these technologies are low-power yet provide great throughput. Small local device networks now have more strength without the usual expense.

LTE-A

LTE-A, or LTE Advanced, offers a significant improvement over LTE technology by expanding coverage while simultaneously lowering latency and improving speed. With its most important uses being in the car, UAV, and similar communication, it provides IoT with a huge power by extending its range.

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Bibliography

[1] Y. Zhang, S. Shao, M. Ji, J. Qiu, Z. Tian, X. Du, and M. Guizani, “An automated refactoring approach to improve IoT software quality,” Appl. Sci., 2020, doi: 10.3390/app10010413.

[2] Y. Simmhan, P. Ravindra, S. Chaturvedi, M. Hegde, and R. Ballamajalu, “Towards a data-driven IoT software architecture for smart city utilities,” Softw. - Pract. Exp., 2018, doi: 10.1002/spe.2580.

[3] Y. Yin, X. Dong, and T. Xu, “Rapid and Efficient Bug Assignment Using ELM for IOT Software,” IEEE Access, 2018, doi: 10.1109/ACCESS.2018.2869306.

[4] S. Nastic, S. Sehic, D. H. Le, H. L. Truong, and S. Dustdar, “Provisioning software-defined IoT cloud systems,” 2014. doi: 10.1109/FiCloud.2014.52.

[5] S. Lempert, IoT-Software-Plattformen. 2021. doi: 10.1007/978-3-658-35127-4.

[6] F. F. Borelli, G. O. Biondi, and C. A. Kamienski, “BIoTA: A Buildout IoT Application Language,” IEEE Access, 2020, doi: 10.1109/ACCESS.2020.3003694.

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