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The **Xiris Glossary** of Machine Vision Terminology



Introduction

Automated welding, camera technology, and digital image processing are all complex subjects. When you combine them in a Weld View Camera system—and factor in the rapid pace of technological change—the terminology used to discuss Weld View Cameras is necessarily somewhat complicated and diverse. To help avoid any confusion, we offer the following glossary of terms.

AC (Alternating Current)

An electric current that reverses its direction at regularly recurring intervals. It is produced by all transformer- type welding machines.

Accuracy

The degree of conformance between a measurement of an observable quantity and a recognized standard or specification that indicates that true value of the quantity. Accuracy normally denotes absolute quality or conformance, while “precision” refers to the level of detail used in reporting the results.

AGC (Automatic Gain Control)

A closed-loop feedback in software regulating the amplification of a digital video signal from a camera to maintain a suitable output signal amplitude, despite variation of the signal amplitude at the input.

Analog Interface Module

An electronic module that allows for the generation of an analog signal suitable to interface with analog devices.

Analog Video Signal

A video signal that takes on a continuous range of values, usually in the range of -1 to +1 volts, which are proportional to the light level acquired at an individual point in the image.

AOI (Area of Interest)

See *Region of Interest (ROI)*.

Aperture

The opening in a lens that determines the cone angle of the bundle of rays that come into focus in the image plane.

Arc Length

The distance between the tip of the electrode and the weld puddle.

Arc On Time

The amount of time that a welding arc is fed power; usually made in reference to the total amount of time available.

Arc Voltage

The voltage across the welding arc.

Artifact

An error in the representation of an item being imaged by a camera. It could be induced in a recorded image by optical issues between light, target, and image sensor, or through the image-acquisition electronics or subsequent image-processing software.

Astigmatism

In imaging, an optical aberration when horizontal and vertical features focus at different depths.

Auto Relearn

A type of re-learn automatically initiated after a certain number of objects have been inspected.

Back Gouging

Carbon-air arc process that utilizes a carbon electrode to melt and blow out weld beads. The process is used to correct defective welds.

Backlighting

When a light source is placed behind an object so that a silhouette of that object is formed. Backlighting is used when outline information of the object and its features are important rather than surface features.

Batch

Any number of items containing the same coded information that is tested sequentially.

Bead

See *Weld Bead*.

Bead Area

The sum of the positional deviations from the ideal profile of the parent material being welded.

Bead Height

The peak deviation from the ideal profile of the parent material being welded.

Bead Position (or Roll Angle)

The angle, on a tube or pipe cross section, between the vertical and a line from the ideal circle's center to the peak point in the bead.

Bead Width

The linear distance between the left and right bead boundary, or bead edge points.

Blob

An arbitrary group of connected pixels in an image. The group of pixels that make up a blob must share a common or similar light intensity. A blob often represents a specific real world object for which measurements need to be obtained for inspection or analysis.

Blob Analysis

The process of extracting blobs from an image and obtaining statistics and other information about those blobs. This information can then be used to determine presence or absence, location, and many other characteristics of the real-world objects these blobs represent.

Blooming

An artifact generated in a camera by an extremely bright light in a scene that causes the charge of one pixel to spill over to adjacent pixels. Most often found on CCD cameras, the effect produces an image with fringes (or feathers) of light extending from the borders of bright areas in an image to darker areas of the image, overwhelming the darker areas of the scene. While modern digital sensors are designed to dissipate excess charge above the full well capacity, excess charge from saturated pixels in very bright parts of the scene can still spill over—leading to saturation in pixels that would not otherwise be saturated.

Breakout Box

A key piece of electrical equipment that supports the integration of a Xiris machine vision system and a host PLC or other machine interface.

Brightness

In imaging, the measure of the radiant power of a feature in a scene as captured on a digital camera sensor and converted to an electric charge.

Butt Joint

A type of joint made between two workpieces in such a manner that the weld joining the parts is between the surface planes of both of the pieces joined. The edges of the material can be square or bevelled. When a butt joint needs to be made with sections too heavy to permit a square butt joint, the sections are beveled, or chamfered, to an angle of approximately 90°. The choice of a single or double bevel will depend upon the thickness of the metal and whether the sections can be welded from the sides. A double bevel uses approximately one-half the amount of weld metal required for a single bevel. The essential factor, in the preparation for welding, is that no part of the joint is left un-welded, whether single or double bevel.

Caliper Tool

A software tool in machine vision that mimics a mechanical caliper tool that measures the distance between two edges, or opposite sides of an object.

'C'-Mount

A recognized standard mount to mount lenses to a camera body: 1" (25 mm) diameter x 32 Threads per inch, with flange-to-sensor distance of 17.53 mm.

CCD (Charge-Coupled Device)

A light-sensitive image sensor used in digital cameras that converts light into proportional (analog) electrical current.

CCIR Video Format

A video standard format used in used in many parts of the world. The picture has 582 lines and uses interlacing between two fields to get a frame. It has horizontal sync rates of 15,625 Hz and a frame rate of 50 Hz. The CCIR electrical signal is a 75 ohm system with a 1.0V (peak-to-peak, including sync) signal. The CCIR standard defines only the monochrome picture component, and there are two major color encoding techniques used with it: PAL and SECAM.

Chevrons

A V-shaped pattern that occurs on the surface of a weld bead caused by inconsistent weld pool flow rate as the weld pool solidifies. This pattern most often occurs in thick-walled-pipe submerged arc welding, where it may be a result of water absorption on the flux used in a submerged arc welding process.

Chromatic

A type of optical aberration when different grey-level intensities focus at different distances or depths. Individual optical lenses may have different sensitivities to specific light wavelengths.

CMOS (Complementary Metal Oxide Semiconductor)

A type of sensor used in digital cameras that is based upon a semiconductor process designed for digital electronics, instead of analog electronics as in the CCD.

CMYK

A subtractive color model, used in color printing and to describe the printing process. CMYK refers to the four inks used in some color printing: cyan, magenta, yellow, and key (black).

Coherent Light

A light source whose individual light rays are in phase with each other and are usually of the same wavelength (i.e., light color).

Coma

In imaging, a type of optical aberration when an off-axis image appears to have asymmetric blurring that is comet-like in shape, giving the appearance of an uneven spot.

Concavity

The maximum perpendicular distance from the face of a concave weld to a line joining the weld toes.

Contrast

The difference in visual properties that makes an object in an image distinguishable from other objects and the background in the image.

Convexity

The maximum perpendicular distance from the face of a convex fillet weld to a line joining the weld toes.

Convolution

A process whereby an image is transformed mathematically by applying a kernel, which is a set of multipliers applied to the neighborhood of each pixel. Imaging applications of convolution include edge detection, sharpening, and smoothing.

Correlation

A mathematical process of comparing a model to an image and determining the similarity (correlation) between the two. The result is a number between 0 and 1, where 1 is a perfect match. This number is referred to as the score.

Crater

A depression at the termination of an arc weld.

Crosshairs

A pair of lines crossing at right angles presented as a graphical overlay at the focus of a feature in an image for use in positioning, aiming, or measuring.

DC (Direct Current)

An electric current that is continuously positive or negative. It is produced by most motor-driven arc welding machines and some rectifier sets.

Defect Size

The number of connected defect pixels within any one defect region.

Difference Magnitude

The degree by which a pixel in the image-under-test varies from the corresponding pixel in a master image.

Difference Image

An image that graphically represents the difference for every pixel, between the master image and the current disc, for a specific inspection.

Difference Inspection

An inspection process where an object is compared to its master based on the color difference between each pixel in the object's image and the same pixel in the master image.

Deflection

The overall deflection of the tube material from an ideal circle as a result of the forming process. Any deflection that occurs will move the starting point of all other defects up or down from the ideal circle.

Depth of Field

The range of an imaging system that is in-focus. It is measured from the distance behind an object to the distance in front of the object where all objects appear in focus. For example, if the object is a weld tip, the depth of field is defined as the distance behind the weld tip to in front of the weld tip where the image is still in focus.

Digital Video Signal

A method of storing, processing, and transmitting image information through the use of distinct electronic or optical pulses that represent each pixel as a combination of binary digits 0 and 1.

Direction of Travel

The direction, relative to the workpiece, in which the weld head is traveling and making weld deposits.

Distortion

An optical aberration in imaging when there is a difference in lateral magnification, usually appearing as a barrel or pincushion effect in the image. It can be minimized by avoiding wide-angle lenses.

Dual Shield

Open-arc process shielded by either granular flux or metal cored tubular wires, along with a secondary shield from external inert gas.

Duty Cycle

The arc on time measured in 10-minute cycles, when the welding power source can operate at rated output.

Dynamic Range

The range of brightness in which a camera can successfully capture the lightest and darkest areas of an image without losing detail. It is usually measured as a multiple, such as 1000:1 (i.e., the brightest feature in an image that can be captured is a thousand times brighter than the darkest feature in an image that can be captured), or in decibels, such as 48 dB. Standard cameras typically have a dynamic range of about 1000:1, but in welding the range of brightness can easily exceed 10,000,000:1, which is greater than 120 dB.

Eddy Current

The most current and predominant testing technology used in the testing of weld integrity. It uses electromagnetic induction to detect flaws in a conductive weld material. The eddy current process can detect sudden changes in the weld seam, but it does a poor job at detecting gradual changes. The reliability of detection of weld-related flaws using eddy current depends on the relative alignment of the seam to the eddy current density. If the seam wanders, the probability of detection diminishes. Also, complex defects with multiple measurement points such as mismatch cannot be effectively detected by eddy current.

Edge

In imaging, a rapid change in light intensity that spans several pixels between two adjacent regions of relatively uniform values. Edges correspond to changes in brightness resulting from a discontinuity in surface orientation, reflectance, or illumination.

Edge Joint

A joint between the edges of two or more parallel or nearly parallel members.

Edge Preparation

The contour prepared on the edge of a joint member for welding.

Edge Strength

Imaging term for an attribute of an edge that indicates the magnitude of the change in light intensity across the edge.

Effective Length of Weld

The length of weld throughout which the correctly proportioned cross-section exists.

Electrode

An electrical conductor used to conduct current through a workpiece to fuse two pieces together. Depending upon the welding process used, the electrode is either consumable, as in the case of GMAW (MIG) processes, or non-consumable, such as in GTAW (TIG) processes. For a DC system, the weld rod or stick may be a cathode for a filling-type weld or an anode for other welding processes. For an AC arc weld, the welding electrode would not be considered an anode or cathode.

EMI (Electromagnetic Interference)

Unwanted signals or noise created by electromagnetic radiation emitted by external electrical circuits carrying rapidly changing signals, such as a welding power supply, as a by-product of their normal operation.

ERW (Electric Resistance Welding)

Low-frequency welding, accomplished through a rotating copper electrode. It is used most often for mild steel tube above 6mm (.250") in diameter. This process is most suitable for the smallest diameters, as the impeders needed for high-frequency (HF) welding cannot fit into the smaller tube diameters. Parent material is rolled from flat to round and welded using electrical resistance to forge the strip edges together. As the welding transformer rotates, the copper electrodes come into contact with the tube edges, heating them so that they can be welded together. The diameter typically ranges from 12mm to 600mm outside diameter. Line speeds range from 60-150m/min. The ERW process is similar to the HF process in that cooling is used, making the addition of an inspection system more challenging.

ERW (Electric Resistance Welded) and HFI (High-Frequency Induction) Welded Pipe

A type of pipe that contains a solid-phase butt weld, originally produced using an ERW welding process to make the longitudinal weld. Now, however, most pipe mills use HFI for better control and consistency. Nonetheless, the product is still often referred to as ERW pipe, even though the weld may have been produced by the HFI process.

Face of Weld

The exposed surface of a weld, made by an arc or gas welding process, on the side from which welding was done.

False Accept

An unacceptable object that is determined acceptable by a measurement or inspection system.

False Reject

An acceptable object that is determined as defective by a measurement or inspection system.

FCAW (Flux Cored Arc Welding)

A semi-automatic or fully automatic welding process in which a tubular electrode containing flux is fed into the welding arc. The flux provides protection of the weld from the atmosphere.

Ferrous Alloys

Metallic alloys that contain predominantly iron, such as cast iron, wrought iron, steel, and stainless steel.

Fiducial

A mark or target, defining a datum point or standard of positional reference, used as a basis for calculation or measurement.

Field of View

The amount of area that can be seen by a camera at one time. It is a result of the size of the image sensor, the lens of the system, and the working distance between object and camera.

Filler Rod

The metal that is added in making a weld in certain types of welding processes, such as GMAW.

Fillet Weld

A weld of approximately triangular cross-section, as used in a lap joint, joining two surfaces at approximately right angles to each other.

Filters

An optical element that can be used to selectively transmit light of different wavelengths, usually implemented as a glass plane or plastic device in the optical path, which are either dyed in the bulk or have interference coatings. Filters can be absorptive, where the light of wavelengths not to be transmitted is absorbed as heat into the filter; or reflective, where the light of the wavelengths not to be transmitted is reflected away from the light path.

Firmware

Permanent software programmed and saved into read-only memory embedded into an electronics circuit.

Flux

A material applied to metal to prevent oxidation during the joining operations, to reduce surface tension, to promote the flow of the alloy, and to facilitate the bonding action between the base metal and the deposited metal. The flux may be a paste, powder, granular, or liquid.

Focal Length

The distance between the lens of a camera and the image sensor when the subject is in focus, usually stated in millimeters.

Focus

An image point or region in which light rays are made to converge. An image point or region is in focus if light from the object points is converged almost as much as possible in the image.

Font

A collection of models, each of which represents a printable character that originates from the same printing source.

FPN (Fixed Pattern Noise)

A particular noise pattern found on digital imaging sensors, often noticeable during longer exposure shots where particular pixels are susceptible to giving brighter intensities above the general background noise.

FPS (Frames per Second)

The rate at which a camera outputs images.

Frame Buffer

The memory designed to store a digitized image. Typically, it resides on a frame grabber card that plugs into an expansion slot of a computer that is capable of capturing an image and storing it. A window to the frame buffer can be identified on a Video Graphics Array (VGA) screen by the picture that can be seen in it.

Frame Grabber

A hardware device that performs image acquisition, storage, and display. It is typically a plug-in adapter for a PC.

Frame Rate

The number of full frames of video that are transmitted per second. Typical NTSC video is 30 frames per second; CCIR is 25 frames per second.

Freeze Line

A line or seam from the surface into the welded area in the shape of a sharp valley. Particularly in ERW and HF welding processes, incomplete heating of the faces of the parent material can sometime occur, resulting in a potentially cold welded joint, which manifests itself as the freeze line in the tube. Such a defect could indicate major problems with the weld, such as cold welding or improper forming. It can very often be a point of a major failure of a weld in high-stress applications because the freeze line acts as a crack initiator into the welded material.

Full Well Capacity

The maximum amount of charge that can be stored in each sensor element in a digital CCD or CMOS camera sensor, where incident photoelectrons are recorded as electric charge.

Gain

The relationship between the number of electrons acquired on an image sensor in a camera and the analog-to-digital voltage level that is generated to provide the image signal.

Gamma

Or Gamma correction, is a nonlinear operation used to encode and decode luminance values in video systems.

Global Camera Shutter

An image-acquisition process used in some types of digital image sensors whereby the entire image is exposed and read out at one time. This provides consistent image features across the entire image, minimizing localized artifacts that could result from variations in movement or brightness while the frame is being exposed. All portions of the image are affected equally.

Globular Transfer GMAW

Named for “globs” of weld metal transferring across the arc in a gravity feed. Droplets across the arc are usually larger than the electrode diameter, producing an unsmooth weld bead appearance, with the possibility of spatter. This process is usually limited to flat and horizontal welding positions and is not used on thin metals.

GMAW (Gas Metal Arc Welding)

A semi-automatic or automatic arc welding process in which metals are joined by heating them with an arc, also referred to by its subtypes: metal inert gas (MIG) welding or metal active gas (MAG) welding. The arc is between a continuously fed filler-metal electrode and the workpiece. GMAW is the most common and readily available metal joining process, preferred for its versatility and speed and the relative ease of adapting the process to automation. There are four basic modes of metal transfer: short-circuit transfer, globular transfer, spray transfer, and pulsed-spray transfer.

Ground Finish

A finish achieved by using a grinder to remove millscale from the surface of raw steel.

GTAW (Gas Tungsten Arc Welding)

Also known as TIG (tungsten inert gas) welding, an arc welding process that uses a non-consumable tungsten electrode to produce the weld. The weld area is protected from atmospheric contamination by a shielding gas, and a filler metal is normally used, though some welds, known as autogenous welds, do not require it. A constant-current welding power supply produces energy that is conducted across the arc through a column of highly ionized gas and metal vapours known as a plasma. GTAW is the slowest process in metal joining, but produces a very high-quality weld with little bead. GTAW is used for pressure-quality welds on 300 series stainless steel, carbon steel, copper, or nickel at slower welding speeds. Parent material is rolled from flat to round and welded using a welding torch with a tungsten tip, usually employing argon or an argon/oxygen mixture as the shielding gas. The torch heats the edges of the strip until the metal begins to melt or puddle, and the next pair of rolls squeezes the strip edges together. Here, edge registration is critical. The tube diameter ranges from 6mm to 150mm outside diameter. Line speeds range from 3-4 m/min.

HAZ (Heat-Affected Zone)

The area of base material that has had its microstructure and properties altered by welding or heat-intensive cutting operations.

HF (High-Frequency) Welding

Today, most mild steel (carbon steel or "carbon black") and aluminum tube is welded with HF welders, which are also suitable for 400 series stainless steel, and even 300 series for some applications. Nearly 95 percent of the HF welders sold are solid state, using transistors to generate the alternating-frequency current. Parent material is rolled and welded using electrical resistance to forge the strip edges together. The diameter ranges from 6mm to 600mm OD. Line speeds range from 60-150m/min. Compared to other welding techniques, HF welding is somewhat forgiving of less-than-perfect edge registration. The HF welding process makes implementing an inspection system rather difficult because copious amounts of cooling are used, generating steam, smoke, and liquid splashes, all of which can impede the optical path of the inspection unit. Special considerations must be made to modify the area of inspection to keep the inspection area clean.

Histogram

A function plotting the frequency of occurrence of an intensity value as a function of those intensity values. As such, a histogram illustrates the distribution of intensity values in a given region of interest in an image.

HMI (Human Machine Interface)

A software application that presents information to an operator or user about the state of a process, and accepts and implements the operators control instructions.

Ideal Tube Profile

The ideal shape of a tube in cross section if the tube were perfectly round.

Image Processing

The transformation of an input image into an output image with desired properties.

Image-Under-Test

The digital image of the object being inspected.

Incoherent Light

A source of light waves that are not all of the same phase and/or wavelengths.

Infrared Camera

Camera that images the weld area after the weld box to determine the profile and penetration of heat in the HAZ. It offers some information but does not provide key quantitative parameter data, such as mismatch measurement.

IP Rating

The "ingress protection" rating as defined international standard EN 60529 and used to define levels of sealing effectiveness of electrical enclosures against intrusion from foreign solids (e.g. tools, dirt, smoke, etc) and moisture.

IR (Infrared) Light

Electromagnetic radiation with wavelengths longer than those of visible light (i.e. > 750 nm) extending to about 1 mm. This range of wavelengths includes most of the thermal radiation emitted by objects near room temperature. Infrared light is emitted by welding processes as a result of the workpiece or weld arc getting hot.

Keyholes

A hole that develops when the sides of the seam undergoing welding burn away to create the weld pool.

LBW (Laser Beam Welding)

A welding process used to join multiple pieces of metal through the use of a laser beam that provides a concentrated heat source, allowing for narrow, deep welds and high welding rates. LBW has high power resulting in small heat-affected zones with good-quality welds and high heating and cooling rates. The depth of penetration is proportional to the amount of power supplied but is also dependent on the location of the focal point. A continuous or pulsed laser beam may be used depending upon the application. Due to the high cooling rates, cracking is a concern when welding high-carbon steels. The speed of welding is proportional to the amount of power supplied but also depends on the type and thickness of the workpieces. The cost of LBW is high relative to that of GTAW, although it is faster. LBW is used primarily for exotic metals (nickel, titanium) and 300 series stainless steel, though some manufacturers use it on 400 series stainless steel as well. Parent material is rolled from flat to round and welded by either a CO₂ or Nd:YAG laser in which a molten puddle is generated between two edges of steel and allowed to solidify to form a weldment. LBW produces the smallest heat-affected zone (HAZ) and a bead even smaller than that produced by GTAW. The focus laser beam creates a keyhole where material is made molten and solidifies. Since there is almost no change in the grain structure of the parent metal, the finished piece has greater flexibility than a GTAW part. However, with this technique, edge registration is more critical than with the others. The tube diameters range from 2mm to 200mm in size. Line speeds range from 8-12m/min.

LED (Light Emitting Diode)

A special type of semiconductor diode that emits incoherent narrow-spectrum light.

Longitudinally Welded SAW Pipe

Welded pipe with a longitudinal seam weld, which is the most popular welding process for large diameter pipe. Double submerged arc welded (DSAW) pipe is welded pipe whose longitudinal butt joint is welded in at least two passes, one of which is on the inside of the pipe. The welds are made by heating with an electric arc between the bare metal electrode. Pressure is not used. Filler metal for the welds is obtained from the electrodes. For diameters above 36", double-seam welded pipe is specified as an alternative in API 5L. Double-seam welded pipe has two longitudinal seams 180° apart, formed by the SAW process. Finished pipes are normally 40 feet (12 m) and occasionally 60 feet (18 m) long, depending on the capacity of the pipe mill and the ease of transport to the pipeline.

Machine Vision

The automatic acquisition and analysis of images to obtain desired data for controlling a specific activity.

Mask

The set of all pixels meeting specific measurement criteria—for example, the set of all pixels which are above a specific brightness.

Master Image

A digital image representing the ideal, or golden part. This is typically constructed by averaging the images of several objects.

Maximum Defect Size

The largest Defect Size allowed. Any larger defect causes a reject.

MCAW (Metal Cored Arc Welding)

A semi-automatic or automatic arc welding process where a continuously fed tubular electrode with a metal core using an external shielding gas is required as filler material. The flux is used to protect against the atmospheric contaminants.

Model

An image representative of a specific feature, which is used to determine the identity of an unknown feature, or to verify the correctness of a known feature.

MIG (Metal Inert Gas) Welding

See *GMAW*.

Millscale Finish

A layer of iron oxide that forms on steel as it leaves the steel mill.

Mismatch

The relative offset from the ideal tube profile between the two bead boundary points on either side of the weld bead area. This phenomenon occurs when the two sides of the parent material are joined unevenly during the welding process. It is of particular concern during tube manufacturing because many tube mills employ a grinder or scarf tool to remove any excess bead that is out of round. If there is mismatch prior to welding, once the tube has been ground down, part of the wall on the high side of the mismatch may get ground down as well, causing significant thinning of the tube wall after grinding the weld area.

Modulated Welding

A method of controlling the power delivered to an electric arc welding head by varying the amplitude, phase, or frequency of a high-frequency periodic waveform, called the carrier signal, with a modulating signal, which typically contains information to be transmitted. Any of these properties can be modified in accordance with a low-frequency signal to obtain the modulated signal. Typically, a high-frequency square wave pulse train is used as carrier signal.

Noise

Irrelevant or meaningless image information resulting from random undesirable video signals or from causes unrelated to the source of data being measured or inspected.

Non-Ferrous Alloys

Alloys that contain little or no iron, such as copper, brass, bronze, nickel, titanium, magnesium, or aluminum.

NTSC

An analog television standard for color television originally in use across most of the Americas and parts of Asia. The standard defines a color video signal that consists of 30 interlaced frames of video per second. Each frame is composed of two fields, each consisting of 262.5 scan lines, for a total of 525 scan lines. The visible raster is made up of 483 scan lines. The remaining scan lines (the vertical blanking interval) are used for synchronization and vertical retrace.

OCR (Optical Character Recognition)

The process by which a string of unknown characters is digitally imaged and converted into machine encoded text by a machine vision system.

OCV (Optical Character Verification)

Optical Character Verification: The process by which a string of known characters is digitally imaged and compared with a set of master images for the purpose of verifying it to be correct by a machine vision system.

OEM (Original Equipment Manufacturer)

A company that offers a product that uses camera systems as a value-additive feature to perform a very specific task. The camera system is treated as value-added and does not represent the central functionality of the OEM's product.

Open Arc Welding

A group of welding processes in which fusion is obtained by heating with an uncovered or open electric arc, or arcs, with or without the use of filler metal.

Operating Dynamic Range

The amount of light variation that can be tolerated. For a camera, it is commonly defined as the ratio between the camera's maximum signal amplitude and its noise floor.

Optics

A branch of physics that involves the behavior and properties of light, including the construction of instruments, such as machine vision devices, that use or detect it. Included in the discipline are various types of optical sources and components, such as lenses, apertures, and filters.

Orbital Welding

A specialized area of welding in which the arc is mechanically rotated 360° around a static workpiece, such as a pipe or tube, in a continuous process.

Overlay

A video plane that typically exists on top of a frame buffer to display graphics. For example, the rectangular frame outlining a viewport is an overlay on the frame buffer image. Generally, an overlay is the video plane that appears "on top" on a video monitor when two or more video signals are mixed.

Path

The route taken by a programmable motion device such as a robot between two points.

PAW (Plasma Arc Welding)

An arc welding process similar to GTAW that can be used to join all metals that can be welded with GTAW (i.e., most commercial metals and alloys) but is an advance over GTAW. The electric arc is formed between an electrode (which is usually but not always made of sintered tungsten) and the workpiece. The key difference from GTAW is that in PAW, by positioning a non-combustible tungsten electrode within the body of the torch, the plasma arc can be separated from the shielding gas envelope. The plasma is then forced through a fine-bore copper nozzle that constricts the arc, and the plasma exits the orifice at high velocities (approaching the speed of sound) and a temperature approaching 20,000°C. PAW has a greater energy concentration than GTAW and therefore allows for deeper penetration and deposition rates.

Photodiode

A semiconductor device that converts light into an electrical current.

Pinhole

A portion of the weld bead where material is missing, visible as a small hole through the weld line.

PIP (Picture in Picture)

The PIP Feature allows for two-tone mapping algorithms to be used on different portions of the screen at the same time, one on the full screen and one on an adjustable inset window. Each tone mapping algorithm has its own settings to enhance key areas of interest in an associated view. The dual tone mapping is performed right in the camera view by using the camera's onboard image processing capability and the image is streamed to an external device as one image.

Pipe/Vessel Cladding

Cladding or weld overlay is a welding procedure that adds weld metal to the surface of the workpieces, as opposed to joining two pieces of material together. Generally, this process is used to provide enhanced corrosion resistance or wear resistance to a pipe or vessel, with a different material used for the cladding layer than for the base metal.

Pixel

An abbreviation for "picture element" (i.e., an individual element of a digitized image array).

Pixelation

An effect in imaging caused by displaying a bitmap image such that neighborhood pixels do not display a smooth transition, causing sharp "steps" visible to the human eye between groups of pixels.

Pixel Jitter

An error introduced into a digitized image caused by analog-to-digital converters attempting to lock sync with the video camera by picking up the horizontal sync pulse using phase-locked-loop (PLL) circuitry. It arises when the horizontal sync for each scan line drifts slightly from the expected position, causing the position of all the horizontal picture elements to be shifted by an equal amount in the scan line.

PoE (Power over Ethernet)

Describes a system which passes electric power along with data on a twisted pair Ethernet cable, allowing a single cable to provide both data connection and electric power to devices such as a weld cameras and a processor.

Pointing Device

A mouse, glide pad, or trackball.

Polarity

An attribute of an edge that indicates the type of transition in light intensity across the edge. A light-to-dark transition is said to have a negative polarity, whereas a dark-to-light transition is said to have a positive polarity. The polarity of an edge is viewed as occurring from the start point towards the end point of a path.

Porosity

Defect in weld structure and appearance caused by trapped gases or impurities.

Pressure Testing

Taking the tube off line, plugging both ends, and filling the tube with liquid under pressure. This is a very slow post-manufacturing process, and defects are found well after all the value-added manufacturing processes. Pressure testing is also a very labor-intensive process.

Processing Mask

The set of pixels which are processed for a given inspection or view.

Pseudo Color

A process when each grey level (or intensity value) in a monochrome image is assigned a color. The resulting image can make the identification of certain features easier for the observer, as the perceived difference in color space for the operator is bigger than between successive grey levels alone.

Pulsed Welding

A form of modulated welding in which the modulation of the power source is done by varying the timing of the waveform.

Pulsed-Spray Transfer GMAW

A variation of spray transfer in which the welding machine "pulses" the output between high peak currents and low background currents. The weld pool gets to cool slightly during the background cycle, making it slightly different than spray transfer. This can allow for welding in all positions on either thin or thick metals.

Raised or Sunken Welds

The material in the bead area that may rise on top of the tube surface (raised weld) or drop below it (sunken weld), depending on the compression force applied on the parent material to make the seam and the weld arc size. A raised weld defect could be indicative of quality problems in the welding process. Conversely, the sunken weld defect is a much more visibly significant defect that could create weakness in the tube along the bead.

RAW Image

An unprocessed image as acquired by the camera without any tone mapping or any additional image processing.

RGB

An additive color model in which red, green, and blue light are added together in various ways to create a broad array of colors.

Region of Interest (ROI)

The area of an image inside defined boundaries that enclose all the features that are to be inspected.

Repeatability

The degree to which repeated measurements of the same quantity vary about their mean.

Roll Angle

See *Bead Position*.

Rolling Camera Shutter

An image-acquisition process used in some types of digital image sensors whereby portions of the image are read out at different times than other portions of the image. This is typically done one line at a time, so one line would be exposed and its current charges read out, then the next line, and so on. The image created from such a shutter can contain artifacts that result from portions of an image being exposed differently than others (e.g., movement, brightness variations).

Root

The base of a weld joint, typically found between two bevelled edges.

Root Pass

The initial pass in a welding process where the weld bead fuses to the root gap at the base of the weld joint.

Rotation

The process in which an image is remapped at 90°, 180°, 270° from the original perspective for operator convenience.

RS170 Video Format

A video standard format used in used in many parts of the world (North America, Japan, and elsewhere). The picture has 525 lines and is displayed 60 times per second, with interlacing between two fields to make a frame. The RS170 electrical signal is a 75 ohm system and 1.0V (peak-to-peak, including sync) signal. The RS170 standard defines only the monochrome picture component, but is mainly used with the NTSC color encoding standard.

Saturation

A type of distortion in a recorded image in which individual pixels are limited to some maximum value, interfering with the measurement of bright regions of the scene. Saturated pixels contain less information about the scene than other pixels and therefore do not contribute much to the quality of an image. Saturation is caused by the physical characteristics of the sensor, particularly the full well capacity of the sensor, which limits the highest irradiance that can be measured for the given settings of the camera.

SAW (Submerged Arc Welding)

An arc welding process in which metals are fused together by heating with an electric arc (or arcs) between a bare metal electrode(or electrodes) and the workpiece. Shielding against oxidation is provided by a blanket of granular, fusible material (much like a sand), usually brought to the work from an external feeder. Filler metal is obtained from the electrode, and sometimes from a supplementary welding rod.

Scarf

The material resulting from the process whereby the excess weld bead is cut off with a knife, or ground off with a grinding tool.

Seam Guidance

A process used to ensure that an arc welding head is properly tracking the seam weld so that the head is in the center of the seam.

Segmentation

The process of separating pixels representing foreground areas of an image from pixels representing background areas of an image.

Shielding Gas

Inert or semi-inert gases commonly used in GMAW and GTAW welding processes. Their purpose is to protect the weld area from atmospheric gases (e.g., oxygen, nitrogen, and water vapor) that could contaminate the weld and reduce its metallurgical integrity.

Short-Circuit Transfer GMAW

A welding process that gets its name from the welding wire actually “short circuiting” (touching) the base metal many times per second. Some spatter is produced, but the transfer can be used in all welding positions and on all thicknesses of metal.

Signal quality

The quality (i.e., electrical cleanness) of a video signal.

Skelp

Flat plates that are formed, bent, and prepared for welding.

SPC (Statistical Process Control)

A method of quality control which employs statistical methods to monitor and control a process to help ensure that the process operates efficiently, producing more specification-conforming products with less rework or scrap. SPC can be applied to any process where the “conforming product” (product meeting specifications) output can be measured.

Spatial resolution

The measure of how closely lines can be measured in a two-dimensional optical image.

Spherical

An optical aberration when rays from the center and edges of the lens focus at different distances.

Spiral Welded Pipe

Pipe created from a process that allows large-diameter pipe to be produced from narrower plates (i.e., skelp), with the welds occurring in a spiral pattern. Early efforts to produce spiral welded pipe resulted in poor dimensional accuracy, particularly “out of roundness” at the pipe ends.

Spray Transfer GMAW

Welding process named for a “spray” of tiny molten droplets across the arc, usually smaller than the wire diameter. This process uses relatively high voltage and amperage values, and the arc is “on” at all times after the arc is established. Very little if any spatter is produced. This process is usually used on thicker metals in flat or horizontal welding positions.

String

A string is a series of one or more characters delineated by a larger space.

Straight Beads

The weld bead that is deposited when the width of the weld deposit is approximately the same as the diameter of the welding electrode.

Sunken Weld

A weld phenomenon where molten material sinks below the ideal tube profile as the weld is cooling.

Tandem GMAW

When two or more welding guns are configured to work in sequence, leading into the same welding puddle. Typically, this process is used to increase welding productivity as more weld material can be deposited faster, with greater welding penetration.

TIG (Tungsten Inert Gas) Welding

See *GTAW*.

Tone Mapping

A technique used in image processing to map a set of brightness levels from one image to another to approximate the appearance of high-dynamic-range images in a medium that has a more limited dynamic range.

Trigger

An electronic signal that initiates an event such as the acquisition of a single or multiple images from a camera.

Tube Mill

A manufacturing line that takes flat strips of steel, aluminum, copper, or exotic material and rolls it into a cylindrical shape for a longitudinal welding process. The tube is produced continuously and then cut to length after the weld has been ground flat, cooled, and shaped.

Ultrasonic Testing

A testing process that uses high-frequency sound vibrations, which are transmitted into material by an ultrasonic transducer. The test instrument then analyzes the ultrasonic signals, which are received using either a pulse-echo or through-transmission method. These ultrasonic non-destructive testing methods will indicate material defects such as longitudinal and transverse cracks, inclusions, and others, as well as interior and outside diameters and significant dimensional changes such as thickness and ovality. The weakness of this testing method is that the sensor has to be perfectly aligned with the seam. Also, it cannot detect small defects or changes, including minor dimensional changes.

Undercut

Weld phenomenon where the laser beam hits the seam between the two sides of the tube in an oblique manner, melting either side of the seam unevenly. This defect may form if the laser beam is too far off center of the ideal welding zone of the tube material. Undercut is actually a non-welded area of the bead on one or both sides of the seam, appearing and behaving like a crack along the bead, creating a very weak point on the weld cross-section.

Underlay

The video plane that appears on a video monitor underneath another plane when two or more video signals are mixed.

Uni-Shield

Open-arc process shielded by granular flux and no secondary gas shield.

UV (Ultraviolet) Light

Electromagnetic radiation with a wavelength shorter than that of visible light (i.e. less than about 750 nm), but longer than X-rays (i.e., greater than 10 nm).

Video Player

A software platform that is capable of playing a digital video file for display on a computer, at full or partial playback speed, sometimes with added processing effects.

Viewport

A two-dimensional region in an image in which special image processing or focus is made.

Virtual Camera

An image container able to hold pre-recorded images and videos for the purposes of display and applying additional image processing.

Visible Light Spectrum

Electromagnetic radiation that is visible to the human eye. Typically defined to have a wavelength between 380 - 750 nm. Some key colors include blue light (around 450 nm), green (about 520 nm), yellow (about 560 nm), orange (about 600 nm) and red (about 700 nm). Note that numbers are approximate.

Weaving

A welding method employed when wider weld beads are required where the electrode is moved from side to side in a weaving motion. The greatest efficiency results from a weave of not more than 2½ times the diameter of the electrode.

Weld Bead

The strip of welded material left after the welding process, usually rising higher than the base material. The feature is usually a combination of melted parent material and filler material used in the welding process.

Weld Crater

A depression at the termination of an arc weld.

Weld Crater Kerfs

The volume between where the original metal existed and the depression at the termination of an arc weld.

Weld Monitor

A device used to collect data on a welding process. It could be a data collection device that records important welding data such as voltage, speed, current, pulse duration, and frequency. Or it could be a Weld View Camera monitoring system that could acquire images of the welding in process for an operator to monitor remotely.

Weld Puddle

The small area of molten metal that forms during welding, immediately after the welding arc. The cooled weld puddle forms the permanent joint. Also known as the weld pool, molten pool, or molten puddle.

Weld Seam

The weld seam is where the two workpieces touch in preparation for welding to occur. Ideally, the weld pool should be centered over the weld seam.

Weld Toe

The point at which the weld face and base metal meet.

Weld View Camera

A camera equipped with the ability to image a High Dynamic Range of brightness to be able to see the brightest features of a weld arc and its dark surrounding environment simultaneously and display the image on a remote monitor so that the operator can view and record the process.

Welding Codes

Welding procedures and standards governing the welding process, as well as consumables.

Weldment

An assembly whose component parts are formed by welding.

Wetting

The behavior of molten parent or filler material when it makes contacts with the solid parent material surface. Molten weld material with poor wetting ability tends to form droplets or spheres, while molten weld material with good wetting ability tends to spread out evenly over the weld bead surface area.

Working Distance

The distance between the end of the camera body and/or camera objective lens and the subject to be imaged.

Workpiece

Two or more pieces of material that are placed together in preparation for fusing together using a welding process.

Zoom Lens

A mechanical assembly of lenses whose focal length can be changed, as opposed to a standard lens, which has a fixed focal length.

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