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When developing an electro optic system in a lab, you can choose a plenty of standard mechatronic solutions on the market, most of them being affordable and providing good performances at the lab level. However, few of them are designed with field applications in mind. In such case, transferring a laboratory proof of concept into a field solution can be painful. Instead, starting with field approved mechatronic solutions will help you go from the lab to the field seamlessly.

Since 1998, CTEC has been working with electro-optic or opto electronic system manufacturers of innovating & high-end industrial vision solutions using CCD & CMOS camera, thermal imager, cooled & un-cooled IR (NIR, SWIR, MWIR & LWIR) camera, for applications such as automated inspection, surveillance & security, night vision, thermal imaging, or free space optical (FSO) communication. CTEC mechatronic components improve the performances of these embedded vision system in terms of image quality & light weight structure. These systems often operate in harsh environment (Land, Sea, Air), with vibrations, thermal amplitude, or altitude. Thanks to this strong heritage, CTEC deliver compact, dynamic and precise products that are intrinsically adapted to field applications.

CTEC mechatronic solutions include XY piezo & magnetic stages, piezo tip tilt platforms & fast steering mirrors as well as linear piezo motorized stages, for applications such as micro-scanning, pixel shift, dithering functions for image resolution enhancement, optical image, laser or line of sight (LOS) stabilization & anti shaking or anti blurring functions for precise target pointing & better image quality.

MICRO-SCANNING STAGE FOR IMAGE RESOLUTION ENHANCEMENT

Microscanning is a key technique in high-resolution IR imaging field. It allows to increase the system resolution and improve the performance of imaging systems. This technique requires repeatability and short response time.

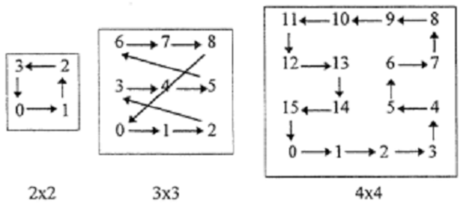

Fig. 1: Typical microscanning patterns

PRINCIPLE

Two technologies are proposed by CEDRAT TECHNOLOGIES (CTEC): moving a lens with a XY25XS Stage or tilting a mirror with a DTT15XS mechanism.

Microscanning technique consists in taking multiple images of the same scene, according to different pattern (Fig.1), while displacing each time the image over the detector plan by a distance equal to a fraction of the detector pitch. The under-sampled frames of the scene are then used to form a single high-resolution frame.

The XY25XS piezo stage shifts a focussing lens in the focal plane array along 2 axis X & Y (Fig.2).

The DTT15XS mechanism tilts a mirror along 2 axis X & Y (Fig.3)

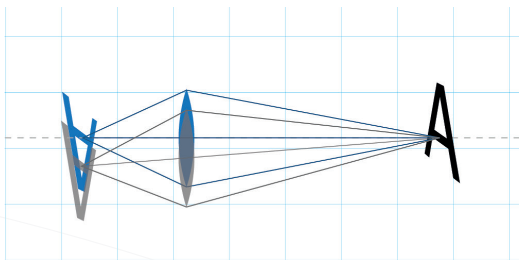

Fig. 2: Lens based microscanning system

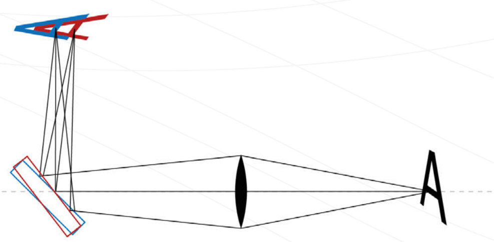

Fig. 3: Mirror-based microscanning system

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MICROSCANNING WITH A XY STAGE

STRUCTURE

The piezoelectric stage XY25XS (Fig.4) is based on standard Amplified Piezo Actuator (APA®) and owns high stiffness. The stage can be equipped with Strain Gauges to get a very fine accuracy. Parasitic rotations are very limited. This compact stage can be customised in order to meet specifications in terms of mechanical integration and environment on board IR camera (Fig.5).

Fig. 4: Standard XY25XS piezoelectric stage

REMARKS

Benefits of the CTEC XY piezo scanner for your IR Camera:

- Elimination of deleterious artifacts from staring arrays
- Elimination of aliasing and spurious response
- Quantitative resolution improvement
- Qualitative Image resolution improvement
- Minimum Resolvable Temperature (MRT) Difference improvement
- Stabilisation improvement / nulling out the residual gimbal jitter

Fig. 5: Catherine IR Camera using a customised XY25XS version, courtesy of Thales Optronique

MICROSCANNING WITH A TIP TILT PLATFORM

STRUCTURE

The piezoelectric DTT15XS (Fig.6) is based on standard Amplified Piezo Actuator (APA®) and owns high stiffness. The DTT mechanism can be equipped with a mirror and Strain Gauges to get a very fine accuracy. This DTT can be customised in order to meet specifications in terms of mechanical integration and environment on board IR camera.

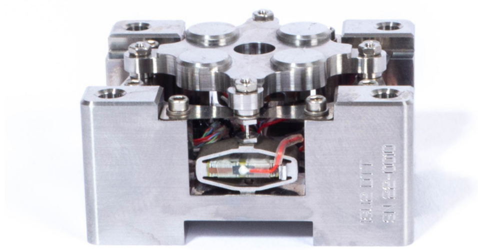

Fig. 6: DTT15XS

ADVANTAGES OF CTEC MECHANISMS (XY25XS & DTT15XS)

- Solid state design
- High speed
- Life time > 10^{10} cycles
- Low chromatic aberration
- Low electric consumption
- Centring in case of failure
- Thermally compensation
- Ease of implementation
- Compact solution

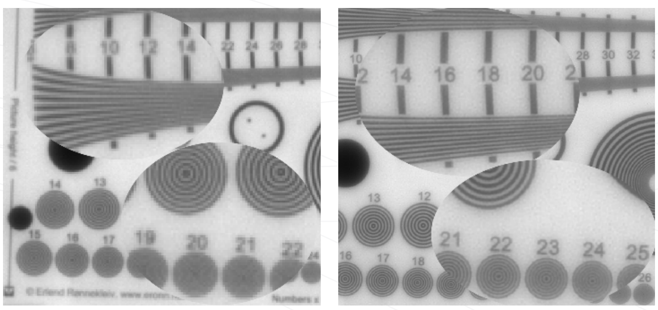

Fig. 7: Left without microscanning.
Right with microscanning

Compared to:

- Prism pair (chromatic aberration)
- Liquid crystals & polarizer (50% input signal attenuation)
- Moving FPA (complicated & limited performances)

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FAST STEERING MIRROR AND XY STAGE FOR IMAGE STABILIZATION

LINE OF SIGHT STABILIZATION

To see far objects with high resolution, an electro system must be switched into a narrow field of view (NFOV) mode, to use a high optical magnification. This NFOV is very sensitive to micro vibrations at sensor level, which makes the resulting image move over several pixels, leading to a blurred image.

Imaging systems are mounted into gimbals, that make a coarse compensation of the low frequency part of the vibration spectrum. Despite this, a remaining error must be corrected. CTEC offers fast steering mirrors and XY stages that address these requirements in the following applications.

GROUND BASED LONG RANGE SURVEILLANCE SYSTEMS

Ground based surveillance systems (Fig. 8) are used for monitoring activities along a border or coast, to protect critical zones or engaged forces, or to counter drones. These surveillance systems are usually installed in open air and mounted on masts. The vibration of the mast due to the wind or ground action will make the resulting image move over several pixels during sensor acquisition, thus blurring the image.

Fig. 8: ground based longe range surveillance system

To counteract these vibrations, XY scanning stages from CTEC (see Fig. 9) are used to move the optical system lens and make sure the focal image is stabilized on the infrared sensor.

Fig. 9: XY300M-SG stage and its CCBu40 controller

EMBEDDED LONG RANGE SURVEILLANCE SYSTEMS

On airborne target designations systems, micro vibrations will drastically spoil the resolution of far looking infrared (FLIR). Despite using a fine gimbal correction system (3rd and 4th axis), remaining micro vibrations still limit the performance of the NFOV to 5 µrad resolution.

A fast-steering mirror solution, based on the DTT15XS-SG tip tilt platform and its controller, is used to correct the remaining high frequencies vibrations, according to the feedback from the gyro and host processor (Fig. 10).

Fig. 10: Embedded long range surveillance system.

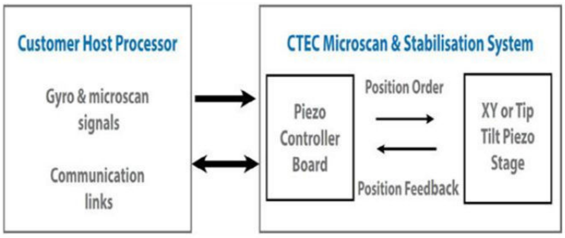

Fig. 12: Vibration correction control strategy

Fig. 11: Fast Steering Mirror with its controller

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ANTI-BLURRING

To enlarge the field of view of an optical device, some imaging systems use a tilting mirror. While this tilting mirror is moving between its 2 extreme positions, the sensor is taking several images that will be then recombined to create a final image with a large field of view.

A system using only one titling mirror will have 2 issues:

- When the sensor is acquiring an image, the mirror is still moving, which results in a blurred image.
- When the sensor is transferring the acquired image to the control system, the mirror is moving, and some part of the scanned image will be lost during this time.

To compensate these 2 issues, a second mirror is used. This mirror will move continuously during an image acquisition, to make sure a fixed image is reaching the sensor. After the acquisition and the image transfer, the mirror will move to the next position, to ensure the continuity of the combined image.

CTEC delivers a TT60SM-SG single axis tip tilt mechanism and a CCBu40 controller to an undisclosed electro optic systems manufacturer, for ground or airborne use.


Fig. 14: TT60SM-SG tip tilt mechanism

Fig. 15: CCBU40 controller

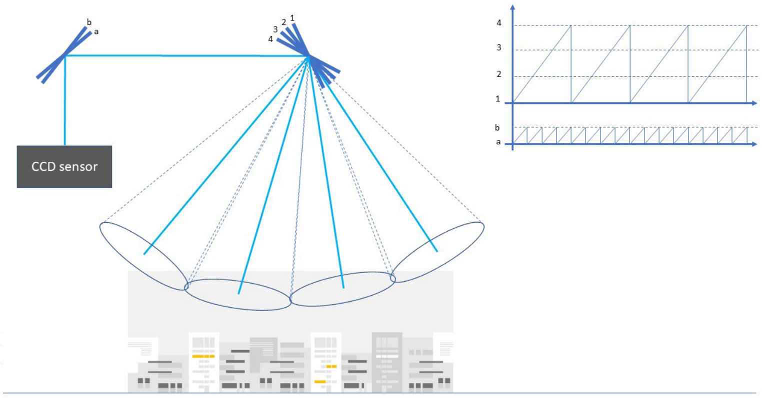

Fig. 13: Two mirrors optical system

BEAM WANDER CORRECTION

Direct energy weapons use high energy lasers to destroy a target such as a missile or a drone, or to make it inoperative. The laser power of such weapons varies from several kW up to 300 kW.

To make sure a laser weapon is efficient, the laser beam must heat the targeted area with a focused beam at a constant place. This ensures the targeted material to heat up and ultimately be destroyed. When the laser beam goes through atmospheric turbulences, its mean position can be randomly deviated. This results in the beam power being diluted in a larger area on the


Fig. 16: Example of laser weapon

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target surface, leading to a lower power density. To compensate this deviation, a fast-steering mirror can be used to stabilize the laser position according to the atmospheric turbulences.

CTEC have been delivering several fast-steering platforms for high energy laser applications (Direct Energy Weapon or laser welding and cutting). The steering platform is designed according to the mirror substrate and optical performances. The pictures below show a few fast-steering mirror solutions based on different platform designs, welcoming either glass or silicon carbide mirror substrates. All these FSM are controlled by CTEC driving electronics, according to dynamic specifications.

Fig. 17: Fast Steering Mirror based on DTT60SM-SG piezo tip tilt platform

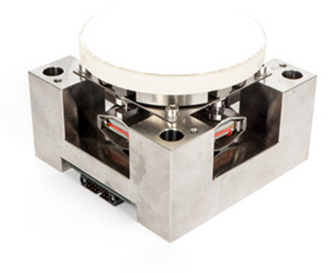

Fig. 18: Fast steering mirror based on DTT40SM-SG piezo tip tilt platform

Fig. 19: Fast steering mirror based on DTT300ML-SG piezo tip tilt platform