DELTA Imaging Path Turbulence Monitor, PM-02-600

Applications

- **Passively monitors turbulence conditions**
- **Laser propagation path characterization**
- **Atmospheric imaging diagnostics**
- **Optical communications link performance**
- **Evapo-transpiration and water management**
- **Include turbulence profiles in wave-optics simulations**
- **Enables custom MATLAB analysis**

Unique Advantages

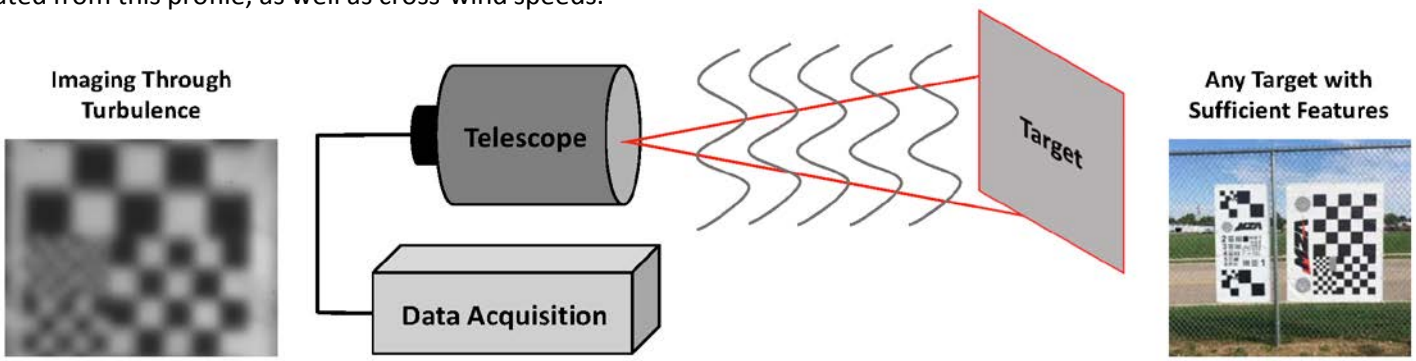
- **Bounds C_n^2 turbulence strength along path**
- **Automatic computation of:**
  - **Rytov number**
  - **Scintillation index**
  - **Fried's coherence diameter**
  - **Isoplanatic angle**
  - **Cross-wind speeds**
  - **Greenwood and Tyler frequencies**
- **2 km range from target to receiver**
- **Automatic collection, processing, and reporting of turbulence diagnostics**
- **Portable and compact system**
- **Passive operation—no external sources required for diagnostic target**
- **Output supports ATMTools and WaveTrain**

Description

MZA's Delayed Tilt Anisoplanatism (DELTA) method measures turbulence strength along a line of sight. These turbulent fluctuations, commonly observed as twinkling of distant lights or stars, significantly affect high resolution imaging sensors and can reduce efficiency of laser beam projection for illumination and optical communications. The same phenomena also give insight into other aspects of the atmospheric path, including evapo-transpiration measures critical to water and agricultural management activities.

Operation

The DELTA system is placed at one end of the path, with a target or object with multiple, trackable features on the opposite end. Depending on the size of the target and the optics on the telescope, a range of ½ to 2 kilometers can be achieved. Once initial setup has been conducted, user desired parameters are adjusted such as feedback period, duration of observation and stored output info. A sequence of imagery is collected and the deviation or "dancing" of feature points on the target is recorded. The DELTA method measures the differential jitter of feature pairs as a function of angular separation. Using multiple pairs at various degrees of separation, a non-uniform C_n^2 profile is estimated using additional atmospheric estimation software. Turbulence statistics are calculated from this profile, as well as cross-wind speeds.



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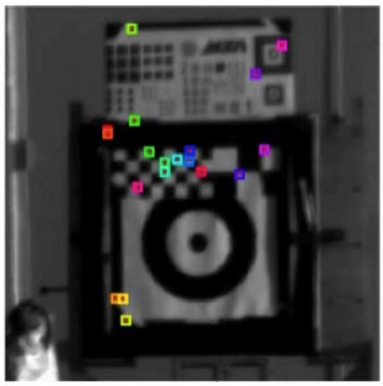
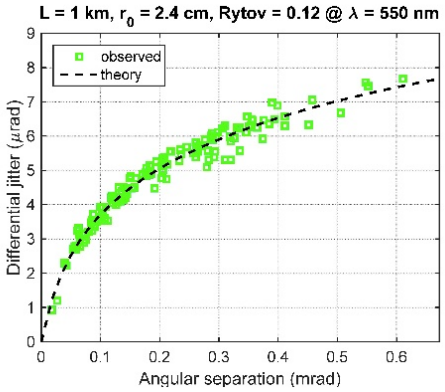
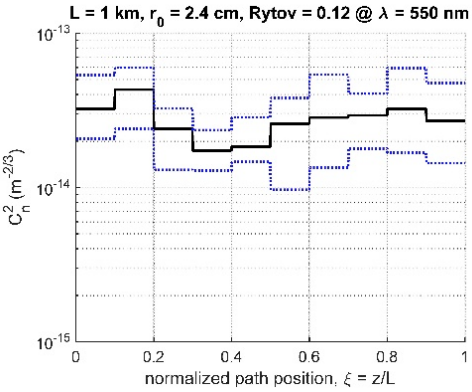
Measured Turbulence Profiles

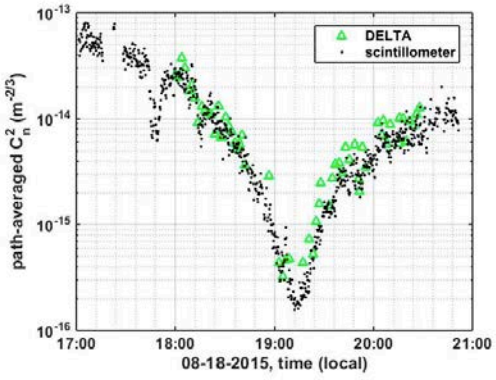
Example of the DELTA method operating over several hours during a live firing test in Albuquerque, NM is shown below. Here, features are extracted off a target board with unique patterns (left). Sub-pixel positions are recorded for each of the features over the full sequence, which is used to compute differential jitter measurements (middle). The C_n^2 profile is then estimated from these values (right), as well as additional turbulence statistics.

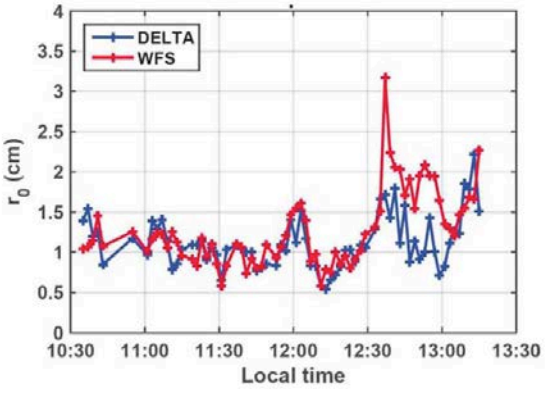
Shown below is a comparison of popular turbulence estimation methods versus the DELTA method. For each comparison, similar results were observed. During the live fire test, a scintillometer recorded results alongside the DELTA system (left). Path averaged C_n^2 values were compared between the two methods. On a separate occasion, the DELTA system was setup next to a Wave Front Sensor (WFS) and simultaneous, side-by-side measurements were recorded. Similar values of r0 were observed between the two sensors.

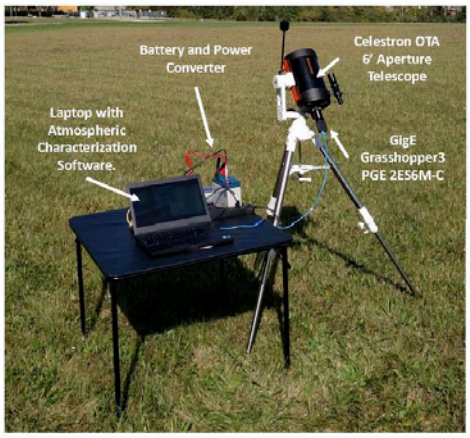












Outputs	Additional Information
Feature Information	Including initial positions, subpixel locations over full image sequence, differential jitter measurements, etc.
Image Sequence	(Optional) Store image sequence. Useful if more experimentation is desired.
C_n^2 Profile	Turbulence statistics including, but not limited to, C_n^2 profiles, Rytov number, and r_0.
Scene & Additional Information	Range, IFOV, embedded camera information (gain, shutter, etc.), wind speed estimates, timestamps, etc.

Grasshopper PGE 2ES6M-C			
Com Interface	GigE	Power Req.'s (V)	5 – 16
Pixel Pitch (μm)	5.86	Full Image Size	1920x1200
Max FOV (mrad)	6.97x4.36	Min FOV (mrad)	0.93x0.70
FPS with Max	46	FPS with Min	214

Physical Req.'s	Weight [lbs]	Footprint [ft]
Tripod & Telescope	25	4
Computer	5	1/2

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