KOPAČKI RIT
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THINKING GNOMON

Experiential Exploration of Time in a Natural Environment

Iskustveno istraživanje vremena u prirodnom prostoru

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FIZIONAR

Introduction

This study proposes a **botanical analemmatic sundial** specifically customized for the unique wetland ecosystem of **Kopački Rit Nature Park - Presentation and Education Centre Tikveš (KRPEC)**, Croatia ($\varphi = +45°41'56''$ N, $\lambda = +18°50'00''$ E). By merging astronomy, gnomonic projection, and ecology, this installation transforms timekeeping into an active, embodied experience. Here, stationary hour markers are living plants and trees whose annual seasonal stages track the Earth's journey around the Sun. A human observer stands upon an analemma date scale, acting as a *"living and thinking gnomon"* whose personal shadow casts the time-indicating ray across the biological landscape [6].

Framework

The living organisms do not perceive abstract, extrinsic space-time; rather, perception is attuned to **physical events** and **ecological events** that possess spatial extent and temporal duration.

A common misconception is that clocks and sundials measure "time" directly. In metrology, this is recognized as a social convention rather than a direct physical measurement [5].

An analemmatic sundial relies on orthographic projection of the Celestial Equator onto the horizon plane, replacing the inclined gnomon with a mobile vertical pointer and the observer's own body functions as the gnomon.

When an observer steps onto the central meridional date scale, they transition from a passive spectator into a **"living gnomon"** whose head serves as the nodus casting the shadow. Upon comprehending the astronomical geometry and orbital kinematics that govern the shadow's direction, the user is elevated to a **"thinking gnomon"** [3, 6]: *measuring spatial angles, not absolute time; structuring ambient light arrays; the embodied observer.*

Celestial Sphere

Sun's apparent motion is described using two reference spheres: **the celestial sphere** (equatorial): right ascension α, hour angle τ, and declination δ; **local celestial sphere** (horizontal): *altitude* h and *azimuth* A.

In the Fig. 1 equatorial coordinates are presented in red color, while the horizontal are colored blue.

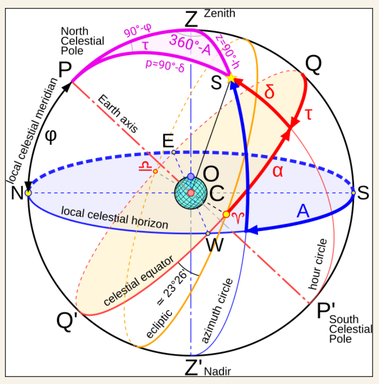
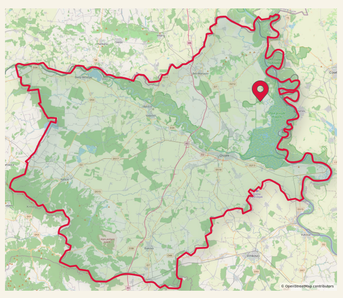


Figure 1: Celestial Sphere[7].

Date Scale and Equation of Time

Because the elliptical hour markers remain stationary, seasonal changes in solar declination δ require shifting the vertical gnomon *North or South* along the meridian date scale by a distance $q = a \cos\varphi \tan\delta$.



To pre-correct for the **Equation of Time (EoT)**, the temporal discrepancy $E := \tau - \overline{\tau} = E_{\text{orbit}} + E_{\text{tilt}}$, between Local Apparent Solar Time (τ) and uniform Civil Mean Time ($\overline{\tau}$) caused by the Earth's orbital eccentricity (E_{orbit}) and axial obliquity (E_{tilt}), the linear date scale is expanded into a two-dimensional figure-eight analemma loop [1, 6] (Fig. 2).

Thus, the horizontal lateral (*East–West*) correction offset p is defined as: $p = a\,(\sin\overline{\tau} - \sin\tau)$.

By stepping onto the coordinate point (p, q) corresponding to the current calendar date, the human gnomon's shadow pre-corrects for solar variance, allowing direct reading of Civil Mean Time.

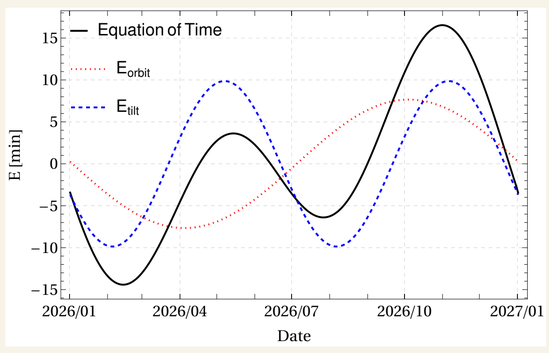


Figure 2: Variation of the Equation of Time, E.

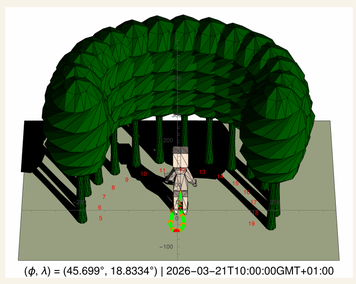
KRPEC Botanical Implementation

In conventional urban sundials, hour markers consist of paved tiles, concrete blocks, or metal pins. In the natural sanctuary of Kopački Rit, we propose substituting these inert markers with **stationary botanical hour markers**.



To function effectively as both precise gnomonic markers and biological indicators, the selected flora must satisfy three strict botanical and spatial criteria: *High Vertical Aspect Ratio and Slender Growth Habit; Perennial Permanence and Ecological Hardiness; Dynamic Phenological expressiveness.*

Based on these structural and ecological requirements, the perimeter of the hour ellipse is planted with a carefully zoned succession of wetland flora, for example: *Lombardy Poplar / Italian Black Poplar* [2].



(a) Human gnomon.



(b) Seasonal Calendar.

Figure 3: Dual Temporal Function.

Dual Temporal Function

The botanical analemmatic sundial functions as a dual-scale ecological clock: *Daily Clock* and *Seasonal Calendar* (Fig. 3a and 3b).

Permanence and Human-Nature Unity

This design physically manifests the fundamental truth that **humans are inseparable from nature**. The observer's physical presence is required to complete the clock.

The Hour Ellipse

The orthographic projection of the circular Celestial Equator onto a horizontal surface at latitude φ generates a perfect ellipse whose semi-major axis a lies along the *East-West* axis and whose semi-minor axis $b = a \sin\varphi$ lies along the *North-South* meridian. The Cartesian coordinates (x, y) of the hour markers along the ellipse perimeter are given by $x = a \sin\tau$ and $y = b \cos\tau = a \sin\varphi \cos\tau$.

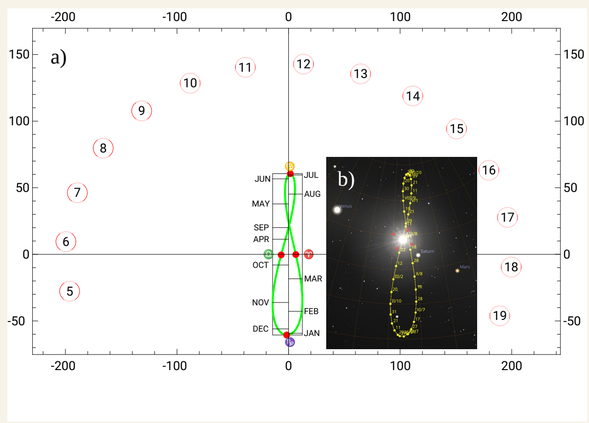


Figure 4: a) Analemmatic sundial planar-view; b) The observational solar analemma recorded at 12 h local mean time [6, 4].

Educational Applications

Through direct interaction with the installation, any observer engages in authentic scientific inquiry and environmental discovery:

- **Observation of Natural Cycles**: The observer actively tracks the daily sweep of solar shadow alongside the seasonal changes of plant life.
- **Conceptual and Spatial Modeling**: The observer connects geometry with astronomical reality, intuitively understanding how the hour ellipse and analemma date scale mirror Earth's planetary dynamics.
- **Functional Validation and Direct Experience**: By stepping onto the analemma date scale as a *"living and thinking gnomon"*, the observer physically tests predictions against actual clock time.
- **Embodied Cognition and Ecological Connection**: As a *"living and thinking gnomon"*, the observer experiences time through bodily position and the changing solar shadow.

Acknowledgement

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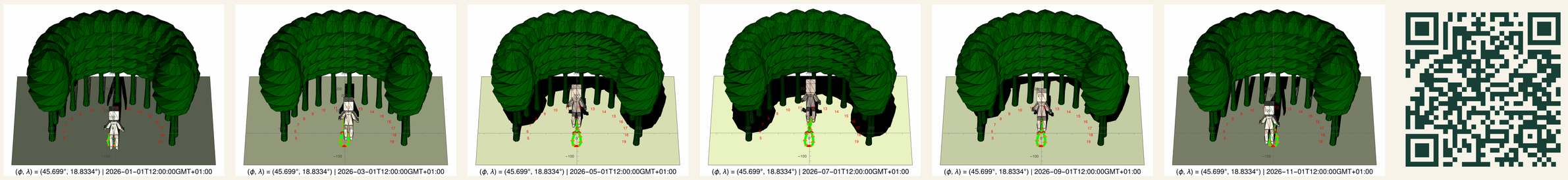
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To enhance visual understanding of celestial geometry and ecological integration, we include structured conceptual diagrams illustrating solar mechanics, the analemmatic layout, and the phenological alignment. (The last QR code leads to the complete animation).



Conclusion

The botanical analemmatic sundial proposed for KRPEC bridges the gap between physics, metrology, geometry, ecology, and botanical science. Thus, it serves as an extraordinary outdoor environment for experiential learning and interpretation.

By replacing clock marks with living flora and static gnomons with human participants, this installation transforms time perception into an active, ecological event. It stands as a sustainable, permanent monument to the unity of human awareness, biological cycles, and celestial mechanics.