e-phenology: The application of new technologies to monitor plant phenology and track climate changes in the tropics

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Keywords: environmental change, tower, database, image processing, new technology

The e-phenology is a multidisciplinary project combining research in Computer Science and Phenology. Its goal is to attack theoretical and practical problems involving the use of new technologies for remote phenological observation aiming to detect local environmental changes. It is geared towards three objectives: (a) the use of new technologies of environmental monitoring based on remote phenology monitoring systems; (b) creation of a protocol for a Brazilian long term phenology monitoring program and for the integration across disciplines, advancing our knowledge of seasonal responses within tropics to climate change; and (c) provide models, methods and algorithms to support management, integration and analysis of data of remote phenology systems. The research team is composed of computer scientists and biology researchers in Phenology. Our first results include: **Phenology tower -** We set up the first phenology tower in our core cerrado-savanna study area at Itirapina, SP. The tower received a complete climatic station and a digital camera. We set up phenology cameras in three more sites: cerrado-savana (Pé de Gigante), cerrado grassland (Itirapina, SP) and rupestrian fields at Serra do Cipo, MG. **Phenology database -** We modeled and implemented the phenology database. The next step is to perform ingestion of legacy data. **Remote phenology and image processing -** We performed the first analyses of the cerrado core site phenology derived from digital images, using different color channels. We analyzed a daily sequence of images (6:00 to 18:00 h) and also the color changes from a two-month set of images. Our results are innovative and indicate the great variation in color change response for tropical trees. We validate the camera phenology with our on-the-ground direct observation in the core cerrado site. **Image processing software –** we are developing a software to automatic process the digital images and to generate the time series for further analyses. **New techniques** have been used to extract seasonal features from vegetation images using visual rhythms and for data processing, using state-of-the-art machine learning approaches. Machine learning was successful applied to identify similar species within the image. Next research steps include: finishing the camera set up on Atlantic rain forest and semideciduous forest, analyses of longer data series with the aim of correlated phenological indices with local climatic data, analyses, and comparison of patterns among different vegetation sites, definition of a comprehensive protocol for digital camera phenology and development of new echonologis to access vegetation changes using digital cameras.

(Financial support: FAPESP - Microsoft Research)