Sixth Solar Information Processing Workshop

13-16 August, 2012

Bozeman, Montana, USA

Introduction

Held since 2003, the Solar Image Processing workshops focus on the extraction of useful information from solar data. The 6th edition will broaden our attention to the more general problem of "Information Processing" and how to obtain the best scientific return out of the petabytes of data that are now available. We will also look at future challenges, such as the even larger data acquisition rates from the Advanced Technology Solar Telescope.

Presentations cover topics such as data reduction, data-mining, three-dimensional reconstruction of solar features, tracking of evolving features in multiple time- and length-scales connecting co-spatial and co-temporal features in multiple wavebands. A demo session will provide interactive discussion on recently developed tools for the quick accessing, browsing, retrieving, and analysis of data.

The Science and Local Organizing Committees would like to thank the following organizations for their support of this meeting:

- NASA Living with a Star Program
- National Science Foundation, Solar Physics Division
- European Space Agency
- Montana State University

Keynote Speaker

Alfred Hero III, University Michigan (*dimensionality reduction, information theory*)

Invited Speakers

Marilena Mierla, Royal Observatory of Belgium (*3D reconstruction of solar structures*)
Kevin Reardon, National Solar Observatory (*Advanced Technology Solar Telescope*)
Fraser Watson, University of Glasgow / National Solar Observatory (*solar cycle studies of sunspots*)

Science Organizing Committee

André Csillaghy, University of Northwestern Switzerland.
Veronique Delouille, Royal Observatory of Belgium.
Thierry Dudok de Wit, CNRS-Orleans.
Jack Ireland, ADNET Systems, Inc./ NASA GSFC, Chair.
Farzad Kamalabadi, University of Illinois at Urbana-Champain.
R. T. James McAteer, New Mexico State University.
Petrus C. Martens, Montana State University.
Alex Young, ADNET Systems, Inc./ NASA GSFC.

Local Organizing Committee

Montana State University
Petrus Martens
Rafal Angryk
Toni Lee

Changes to this document will be made available via
http://www.sipwork.org/sipwork-vi-final-announcement/.

Schedule

Monday, 13 August 2012 morning

Key	Keynote Talk	Invited Talk	Working Groups
	Coffee Break / Poster session	Lunch	
		Title	*Presenter (last name, first initial)*
Morning			
	9:00 - 9:15 am	*Welcome Address*	*Ireland, J., and Martens, P.*
Chair: J. Ireland			
Session 1: Instrumentation and solar image processing,	9:15 - 9:55	Image Processing and Feature Recognition for High-Resolution Solar Imaging	Reardon, K.
	9:55 - 10:15	Mainstreaming High-Energy Solar Data	Csillaghy, A.
	10:15 - 10:35	Identifying Transient Features in the Solar Atmosphere From Multiple Sources	Kirk, M.
	10:35- 10:55	Revealing structures and dynamic phenomena on ground-based coronagraph observations via a multi-resolution approach	Lopez, F.
	10:55 - 11:25	*Coffee Break / Poster Session*	
Chair: Barbara Thompson			
Session 2: Reconstruction of three dimensional structure of the solar atmosphere	11:25 - 12:05	3D reconstruction of coronal mass ejections: where are we?	Mierla, M.
	12:05 - 12:25	Toward Tomographic Reconstruction of CMEs With a Phase Field Method	Hewett, R.

Monday, 13 August 2012 afternoon

Afternoon			
	12:25 - 1:30	*Lunch*	
Chair: Barbara Thompson			
Session 2 (continued): Reconstruction of three dimensional structure of the solar atmosphere	1:30 - 1:50	Vector Tomography for the Coronal Magnetic Field	Kramar, M.
	1:50 - 2:10	3D reconstruction of CMEs from 3-viewpoints, method comparisons and applications	Feng, L.
	2:10 - 2:30	CME Reconstruction from Three Viewpoints Via Simulation Morphing	Frazin, R.
	2:30 - 2:45	Challenges in Solar Image Processing	Ireland, J.
	2:45 - 3:00	Introduction to Working Group 4	Davey, A. R.
	3:00 - 3:30	*Coffee Break / Poster Session*	
Working Groups	3:30 - 5:15	Working Groups parallel sessions	
Evening			
	5.30 pm	Welcome Reception at the Alumni Room in the Strand Union Building on the MSU campus.	

Tuesday, 14 August 2012 morning

Key	Keynote Talk	Invited Talk	Working Groups
	Coffee Break / Poster session	Lunch	
		Title	*Presenter (last name, first initial)*
Morning			
Chair: F. Kamalabadi			
Session 3: Solar information and image processing techniques	9:00 - 10:00	Graphical modeling for high dimensional data analysis	Hero, A.
	10:00-10:20	Using DEM Algorithms for Coronal Data	Plowman, J.
	10:20 - 10:40	Multi-order slitless solar spectroscopy: a Parametric Inversion Approach	Oktem, S. F.
	10:40 – 11:00	CORIMP: Automatically Detecting & Tracking CMEs in Coronagraph Data	Byrne, J.
	11:00 - 11:30	*Coffee Break / Poster Session*	
	11:30 - 11:50	Detection of small-scale features in the solar photosphere using segmentation algorithms	Cabello Garcia, I. B.
	11:50 - 12:10	Spatio-Temporal Co-occurrence Pattern Mining in Solar Events	Ganesan Pillai, K.

Tuesday 14 August 2012 afternoon

Afternoon			
	12:10 - 1:30	*Lunch*	
Working Groups	1:30 - 3:30	Working Groups parallel sessions	
	3:30 - 4:00	*Coffee Break / Poster Session*	
Working Groups	4:00 - 5:15	Demos from WG 4 in Reid Hall	
		Table 1	Table 2
	4:00-4:20	Analysis of SDO Data for propagation of waves and other features using a graphical user interface based IDL package by L. Jeska	Expanding the Helioviewer Project by J. Ireland
	4:20-4:40	SunPy: Python for Solar Physics Data Analysis by V. Hughitt	The Virtual Solar Observatory by J. Sattelberger
	4:40-5:00	HELIO - All the heliosphere in your hands by D. Perez-Suarez	Heliophysics Event Knowledgebase for the Solar Dynamics Observatory and Beyond by R. Timmons
Evening			
		nothing scheduled	

Wednesday 15 August 2012

Key	Keynote Talk	Invited Talk	Working Groups
	Coffee Break / Poster session	Lunch	
		Title	*Presenter (last name, first initial)*
Morning			
Chair: A. Csillaghy			
Session 3: continued	9:00 - 10:00	Learning with entropic graphs	Hero, A.
	10:00 - 10:20	Towards the Pseudo-Automatic Characterization of the Morphological and Kinematical Properties of Coronal Mass Ejections using a texture-based Technique	Stenborg, G.
	10:20 - 10:40	Filament and Sigmoid Statistics Gathered by Newly Developed Automated Feature Finding Modules	Martens, P.
	10:40 - 11:00	An overview of tools and techniques for parallel computation in solar image processing	De Visscher, R.
	11:00 - 11:30	*Coffee Break / Poster Session*	
	11:30 - 11:50	Principle Component Analysis of the solar background and sunspot magnetic fields in the cycle 21-23.	Zharkov, S.
	11:50 - 12:10	Poisson noise reduction with non local PCA	Salmon, J.
Afternoon			
	12:10 - 1:30	*Lunch*	
Working Groups	1:30 - 3:00	Problem solving sessions - big challenges in Solar Image Processing	
	3:00 - 3:30	*Coffee Break / Poster Session*	
Working Groups	3:30 - 5:15	Working Groups parallel sessions	
Evening			
	6:00 - 11:00	*Conference Dinner at the Emerson Center in downtown Bozeman*	

Thursday 16 August 2012

Key	Keynote Talk	Invited Talk	Working Groups
	Coffee Break / Poster session	Lunch	
		Title	*Presenter (last name, first initial)*
Morning			
Chair: V. Delouille (9:00 - 11:00), D. Lamb (11.30 - 12:30)			
Session 4: Segmentation and tracking of solar features.	9:00 - 9:40	A systematic look at sunspots from space: 1996-2011	Watson, F.
	9:40 - 10:00	SWAMIS Emerging Flux Detection and Magnetic Feature Tracking for SDO	Lamb, D.
	10:00 - 10:20	Image Processing and Pattern Recognition: General Approaches and Application to Solar Data	Boucheron, L.
	10:20 - 10:40	Spatio-Temporal Evolution Tracking of Solar Flares	Aschwanden, M.
	10:40 - 11:10	*Coffee Break / Poster Session*	
	11:10 - 11:30	Tracking the Elusive Polar Coronal Hole	Pesnell, W. D.
	11:30 - 11:50	Segmentation of Coronal Holes Using Active Contours and Detection of Small Boundary Flashes	Valluri, M.
	11:50 - 12:10	Coronal Hole Detection on SDO images	Delouille, V.
Afternoon			
	12:10 - 1:30	*Lunch*	
Working Groups	1:30 - 3:00	Reports from the Working Groups and Closing Remarks	
Evening	7:30 – 8:30	*Free celestial-themed jazz concert at the Reynolds Recital Hall on MSU Campus with Jeni Fleming (http://www.montanapbs.org/11thGrantwithEricFunk/episode101/)*	

Friday 17 August 2012

All Day		Excursion to Yellowstone National Park
	6:00 - 7:00 am	Conference hotel breakfast starts at 6am.
	7:00 am - 9:00 pm (approximately)	Leave from the conference hotel (Holiday Inn Bozeman) at 7:00 am.Lunchboxes and drinks (in coolers) come on the bus and are included in the price. Tour group can stop at some gorgeous picnic area in the park. Dinner is at a typical and inexpensive Montana BBQ place outside the park on the way back, between approximately 6 and 7 pm (depending on the route). Estimated arrival back at the hotel is 9pm.

Poster Session
13-16 August

Poster Number	*Title*	*Presenter (last name, first initial)*
1	Automated and Interactive Image Analysis at NOAA's Space Weather Prediction Center	*Hill, S.*
2	Automatic Classification and Tracking of Solar Features	*Stenning, D.*
3	Evaluating Automated Solar Event Detection	*Schuh, M.*
4	Dimming and EIT wave detection on SDO/AIA: first results by NEMO	*Kraaikamp, E.*
5	The Coronal Pulse Identification and Tracking Algorithm (CorPITA) for automated detection of "EIT Waves"	*Perez-Suarez, D.*
6	Polarity Inversion Line Module	*Engell, A.*
7	Automatic finding, tracking, and analysing sunspots and white light faculae	*Gyori, L.*
8	Automated Classification of Flaring Behavior in Solar Active Regions	*Al-Ghraibah, A.*
9	Quantitative Heliospheric Imaging: how to separate 99.9% of your data (and have something left)	*DeForest, C.*
10	On the use of the Dual Tree Complex Wavelet Transform on white light coronal images	*Stenborg, G.*
11	Analysis of SDO Data for propagation of waves and other features using a graphical user interface based IDL package.	*Jeska, L.*
12	Applying Computer Vision to SDO/AIA images	*Felix, S.*

Poster Session 13-16 August

Poster Number	*Title*	*Presenter (last name, first initial)*
13	Calibration of Hinode/XRT for Coalignment	*Yoshimura, K.*
14	Polarization Fringe Removal Using Wavelet Analysis	*Harker, B.*
15	Compressing SDO's FITS image files, a study from an image-processing perspective	*Banda, J.*
16	How SDO Changed Solar Physics?	*Davey, A.*
17	SunPy: Python for Solar Physics Data Analysis	*Hughitt, V.*
18	Extending the usage of the Helioviewer Project	*Ireland, J.*
19	HELIO - All the heliosphere in your hands.	*Perez-Suarez, D.*
20	The Virtual Solar Observatory	*Sattelberger, J.*
21	Heliophysics Event Knowledgebase for the Solar Dynamics Observatory and Beyond	*Timmons, R.*
22	Feature Recognition in Heliophysics Integrated Observatory	*Zharkov, S.*

Keynote talks

Hero, A.

Graphical modeling for high dimensional data analysis

Co-Authors:

Affiliation of presenter: University of Michigan

Working Groups: Solar information processing techniques

Abstract:

We will describe a graphical modeling framework for analyzing high dimensional datasets. Graphical models capture conditional independencies between variables and can be used for model reduction. Two problems will be addressed: dimensionality reduction through matrix factorization and dimensionality reduction through partial correlation network models. The methods are scalable to high dimensions and have been used to extract structure from high dimensional datasets in remote sensing imagery and gene expression time course data.

Hero, A.

Learning with entropic graphs

Co-Authors:

Affiliation of presenter: University of Michigan

Working Groups: Solar information processing techniques

Abstract:

Entropy is a higher order extension of second order measures, like variance and correlation, that characterize uncertainty in terms of the spread of a distribution or conditional distribution. Entropy minimization principles can be used to generalize correlation methods such as principal component analysis (PCA), linear discriminant analysis (LDA), and other linear models for doing data fusion, feature extraction, and anomaly detection. Entropy can be estimated using entropic graphs such as k-nearest neighbor graphs constructed over the feature space. Entropic graphs have been applied to data analysis tasks including image registration, intrinsic dimension estimation, spectral clustering, and anomaly detection.

Invited talks

Mierla, M.

3D reconstruction of coronal mass ejections: where are we?

Co-Authors: L. Feng, L. Rodriguez, I. Chifu, B. Inhester

Affiliation of presenter: Royal Observatory of Belgium, Brussels, Belgium

Working Groups: Reconstruction of the three-dimensional structure of the corona

Abstract:

Coronal mass ejections (CMEs) display various shapes in white-light coronagraph images. They are very energetic, complex phenomena, which, when interacting with the Earth magnetic field can produce major disturbances affecting us directly. This is why it is important to know in advance their speed, their direction of propagation and their 3D shape. The data from STEREO, launched in October 2006, helped us get a better insight in the 3D complexity of CMEs. Up to now, all the reconstruction methods applied to CMEs did a good work in deriving their true speeds and their direction of propagation. There is still a lot to do in deriving their true 3D shapes. We will present in this talk an update of what was done so far on this aspect. We will outline the constraints on reconstructing the CMEs and possible improvements with the next generation of space missions.

Reardon, K.

Image Processing and Feature Recognition for High-Resolution Solar Imaging

Co-Authors:

Affiliation of presenter: National Solar Observatory

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength; Solar information processing techniques; Accessing, browsing, retrieving data

Abstract:

High-resolution imaging of the solar atmosphere is crucial for the study of fundamental physical processes driving the Sun's behavior. A large quantity of data is produced by existing telescopes and the Advanced Technology Solar Telescope will increase the data flux by an order of magnitude or more. The challenge is to extract from these large volumes of data a variety of useful information that will enable broad scientific exploration. The use of automated image processing techniques and feature recognition algorithms will play a key role in the processing of these data. I will describe the issues related to the processing of ground-based, high-resolution solar data, often affected by variable seeing conditions, and show examples of feature recognition applied to such data sets. I will also discusses areas of algorithm development and adaption that are needed for the analysis of these high-resolution data.

Watson, F.

A first systematic look at sunspots from space: 1996 - 2011

Co-Authors: Lyndsay Fletcher

Affiliation of presenter: University of Glasgow / National Solar Observatory

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength

Abstract:

The Sunspot Tracking and Recognition Algorithm (STARA) is a tool developed for the purposes of detecting and tracking sunspots in long time-series data sets. We use STARA to create a database of all sunspots observed in SOHO/MDI and SDO/HMI continuum data in a consistent manner. This database is then used to determine a number of properties such as sunspot lifetimes, growth rates and long term changes over the cycle, all of which are important parameters in modelling of the solar dynamo and solar magnetic fields. This is the first study of sunspots using space based data covering more than one solar cycle and solar image processing techniques are essential to enable these datasets to be processed quickly, and consistently.

Contributed Talks

Aschwanden, M.

Spatio-Temporal Evolution Tracking of Solar Flares

Co-Authors:

Affiliation of presenter: Solar and Astrophysics Laboratory, Lockheed Martin ATC

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength

Abstract:

We explore the spatio-temporal evolution of solar flares by threshold-based tracking of flaring areas in different soft X-ray and EUV wavelengths, in order to extract the time evolution of fundamental geometric and temporal parameters, such as length scales L(t), areas A(t), volumes V(t), fractal dimensions D(t). We demonstrate the technique by analyzing 155 M-class and X-class flares observed with GOES and AIA/SDO. This automated data analysis technique is relevant to study various spatio-temporal evolutionary physical models, such as Brownian motion, fractal Brownian motion, random walk, classical diffusion, sub-diffusion, super-diffusion, hyper-diffusion, Levy flights, logistic growth, percolation, self-organized criticality avalanches, cellular automatons, non-extensive Tsallis entropy, complex networks, etc.

Byrne, J.

CORIMP: Automatically Detecting & Tracking CMEs in Coronagraph Data

Co-Authors: H. Morgan, S. R. Habbal, P. T. Gallagher

Affiliation of presenter: CORIMP: Automatically Detecting & Tracking CMEs in Coronagraph Data

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength

Abstract:

Studying CMEs in coronagraph data can be challenging due to their diffuse structure and transient nature. Furthermore, user-specific biases may be introduced through visual inspection of the images. The large amounts of data available from the SOHO, STEREO and future coronagraph missions, also makes manual cataloguing of CMEs tedious. So, a robust method of detection and analysis is required. This has led to the development of automated CME detection and cataloguing packages such as CACTus, SEEDS and ARTEMIS. Here we present the development of a new CORIMP (coronal image processing) CME detection and tracking technique that overcomes many of the drawbacks of current catalogues. It works by first employing a radial filter and dynamic CME separation technique to remove the static background, and then characterising CME structure via a multiscale edge-detection algorithm. The detections are chained through time to determine the kinematics and morphology of the CME as it propagates across the plane-of-sky.

Cabello García, I. B.

Detection of small-scale features in the solar photosphere using segmentation algorithms

Co-Authors: L. Balmaceda , V. Domingo , J. Blanco Rodríguez , J. A. Bonet

Affiliation of presenter: Image Processing Laboratory-Universidad de Valencia (España)

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength

Abstract:

The study of small magnetic structures in the solar photosphere is of great relevance for the understanding of the global behavior of the Sun. Because of the small spatial and temporal scales involved, the use of high resolution images is fundamental for their study. In order to obtain such images, sophisticated computational techniques that compensate for the atmospheric degradation and telescope aberration have been developed, improving in this way the spatial resolution. In this work, we use G-band images obtained with the 1m-Swedish Solar Telescope located at La Palma (Canary Islands, Spain) and restored with MFBD (Multi-Frame Blind Deconvolution), a technique that combines multiple images acquired in a short time interval. The resulting images have a resolution close to the diffraction limit of the telescope (0."1) allowing the study of the properties of very small bright structures present in the inter-granular lanes in the solar photosphere, known as Bright Points. In order to detect such small-scale features, algorithms based on image-segmentation are used. This study shows the results obtained after applying two algorithms of this kind: the one designed by Sanchez Almeida et al. (2004) and MLT4 developed by Bovelet and Wiehr (2007). We compare their performance based on the number of features successfully detected, the time necessary to do the task and the level of interaction required from the user to select these features.

Csillaghy, A.

Mainstreaming High-Energy Solar Data

Co-Authors: Laszlo Etesi, Nicky Hochmuth for the HEPSE team

Affiliation of presenter: University of Applied Sciences Northwestern Switzerland, Institute for 4D Technologies

Working Groups: Solar information processing techniques

Abstract:

In this paper, we present our concepts and first results of the European FP7 project High Energy Solar Physics in Europe (HESPE). This project aims at releasing large amounts of science-ready data products from solar X-ray observations done by the NASA's Reuven Ramathy High-Energy Solar Spectroscopic Imager (RHESSI). RHESSI is an indirect imager, thus images must be reconstructed from photon counts before they can be analyzed. Our project aims at replacing the manual image reconstruction by an automatic processing framework. At its core, an optimization algorithm selects optimal time and energy intervals for image reconstruction. The HESPE framework will not only be applicable to RHESSI, but will prepare the grounds for the data management of the next X-ray instrument STIX, which will fly on Solar Orbiter.

De Visscher, R.

An overview of tools and techniques for parallel computation in solar image processing

Co-Authors:

Affiliation of presenter:

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength; Reconstruction of the three-dimensional structure of the corona; Solar Information processing techniques; Accessing, browsing, retrieving data; Problem-solving session

Abstract:

Solar image processing is performed on vasts amount of data. These applications can usually benefit greatly from parallellization and distributed processing. This talk will present an introduction to tools and techniques for accelerating solar image processing software. Both general parallel processing topics, such as memory locality and parallellization techniques, as well as specific tools like OpenMP, CUDA and Hadoop will be considered. Finally, examples of how these tools and techniques can be used for the solar image processing software SPoCA and Velociraptor will be given.

Delouille, V.

Coronal Hole Detection on SDO images

Co-Authors: B. Mampaey, C. Verbeeck, R. DeVisscher

Affiliation of presenter: STCE/Royal Observatory of Belgium

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength; Solar Information processing techniques; Accessing, browsing, retrieving data; Problem-solving session

Abstract:

Coronal holes (CH) are the darkest and least active regions of the Sun, as observed both on the solar disc and above the solar limb. CHs are associated with expanding open magnetic fields and the acceleration of the high speed solar wind. For space weather purpose it is therefore important to locate precisely the coronal holes on EUV images. We have developed SPOCA-CH, an algorithm for extracting and tracking Coronal Holes in EUV images. SPOCA-CH is based on Fuzzy C-Means algorithm and is applied on square root of 19.3nm SDO-AIA images. We describe the algorithm, and present the results obtained on a dataset ranging from June 2010 till May 2011. We study the distribution in intensity inside the CHs, and compare it to the one of the Quiet Sun. Next, we validate the results by combining them with information coming from other instruments such as SDO-HMI magnetograms. The SPoCA-CH module is implemented within the HEK, and provides boundary localisation of coronal holes in near real time

Feng, L.

3D reconstruction of CMEs from 3-viewpoints, method comparisons and applications

Co-Authors:

Affiliation of presenter: Purple Mountain Observatory, CAS, China

Working Groups: Reconstruction of the three-dimensional structure of the corona

Abstract:

A new mask-fitting method has been devoloped to derive the 3D periphery of CMEs. STEREO/COR 1 & 2, LASCO/C2 &3 data observed from three viewpoints are utilized to obtain the 3D CME volume as precise as possible (Feng, et al. ApJ, 2012). This new method has been compared to geometric localisation, GCS forward modelling, polarisation ratio method, and LCT plus triangulation. The propagation direction and spatial extent from these five methods are presented (Feng, et al, Solar phycics, to be accepted). The new mothod provides more accurate results than the reconstructions from only two views and is not limitted to any pre-defined CME shape. It can be used to solve the ambiguity in the polarisation ratio method and its spatial extent is consistent with the overlap region of the CME localisations derived from COR A and COR B data, respectively, using the polarisation. The current version of the code does not include the internal structures inside a CME. Further improvements will go to this direction. As an application of this new mask fitting method, its spatial extent has been used to derive a more precise CME mass and energetics from 3-viewpoints. The free magnetic energy is derived from HMI/SDO measurement using the NLFFF method. The energy partition between CME and flare are investigated. The flare energy is estimated using GOES, RHESSI and EVE/SDO.

Frazin, R.

CME Reconstruction from Three Viewpoints Via Simulation Morphing

Co-Authors:

Affiliation of presenter: University of Michigan

Working Groups: Reconstruction of the three-dimensional structure of the corona

Abstract:

The problem of reconstructing the three dimensional (3D) density distribution of a coronal mass ejection (CME) from three simultaneous coronagraph observations is timely in that the COR1 and COR2 coronagraphs on the STEREO mission complement the LASCO coronagraphs on SOHO and the Mk4 on Mauna Loa. While the separation angle between the STEREO spacecraft and the Earth depends on the time since the launch in 2006, but the reconstruction problem is always severely under-informed. So far, all 3D reconstruction efforts have made use of parameterized models in order to determine the 3D structure of the CME. Such approaches do not utilize the power of 3D MHD simulation to inform the reconstruction. This papers considers the situation in which a specific CME event observed in corongraphs from three viewpoints is later simulated by solving MHD equations. The reconstruction is then subjected to an invertible morphological morphing operator chosen so that morphed MHD simulation is most consistent with the 3-viewpoint coronagraph data. The morphological operations are explained mathematically and synthetic examples are given. The practical application to reconstructing CMEs from STEREO and SOHO data is discussed.

Ganesan Pillai, K.

Spatio-Temporal Co-occurrence Pattern Mining in Solar Events

Co-Authors:

Affiliation of presenter: Montana State University

Working Groups: Solar Information processing techniques; Accessing, browsing, retrieving data

Abstract:

Spatio-temporal co-occurring patterns (STCOPs) represent subsets of event types that occur together in both time and space. In this work, we demonstrate applicability of our STCOP discovery algorithm for identifying interesting STCOPs between solar events reported in Heliophysics Event Knowledgebase.

Hewett, R.

Toward Tomographic Reconstruction of CMEs With a Phase Field Method

Co-Authors: I. Jermyn, M. T. Heath, F. Kamalabadi

Affiliation of presenter: Massachusetts Institute of Technology

Working Groups: Reconstruction of the three-dimensional structure of the corona; Solar Information processing techniques; Problem-solving session

Abstract:

Current techniques for solar tomography are insufficient for computing 3D empirical models of coronal mass ejections (CMEs) due to spatial and temporal sparsity in the data. Additional information, in the form of geometric constraints enforced by augmenting the classical data misfit energy with a phase field energy, can be used to mitigate some of the difficulty and improve reconstruction quality from sparse data. The phase field approach utilizes a neutral starting condition and easily handles complicated topologies without additional heuristics. We use a robust variant of Newton's method and a flexible finite element discretization to minimize the joint image segmentation and tomography energy. We demonstrate results from our model which encourage further development for application in 3D to CME data.

Kirk, M.

Identifying Transient Features in the Solar Atmosphere From Multiple Sources

Co-Authors:

Affiliation of presenter: Department of Astronomy, New Mexico State University.

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength; Solar Information processing techniques; Accessing, browsing, retrieving data; Problem-solving session

Abstract:

Both space-based and ground-based observations of the solar atmosphere have their unique benefits and drawbacks. To form a complete picture of their origin and evolution, it is critical to observe dynamic features at multiple heights and temperatures. This necessitates using ground-based and space-based images simultaneously. We present an automated technique for identifying and tracking ephemeral chromospheric bright features adjacent to eruptions. The meta-data produced in this tracking process is then culled to isolate trends and anomalies in solar eruptions. We utilize the ground-based ISOON telescope and extend these detections vertically into the corona by pairing them with complementary AIA images. Through a multi-instrument approach to automated analysis, we are able to constrain the energy produced in, and postulate an origin of eruption associated ephemeral brightenings

Kramar, M.

Vector Tomography for the Coronal Magnetic Field

Co-Authors: H.Lin, B.Inhester, J.Davila, S.Tomczyk

Affiliation of presenter: The Catholic University of America / NASA-Goddard Space Flight Center

Working Groups: Reconstruction of the three-dimensional structure of the corona

Abstract:

Magnetic fields in the solar corona dominates the gas pressure and therefore determine the static and dynamic properties of the corona. Direct measurement of the coronal magnetic field is one of the most challenging problems in observational solar astronomy and recently a significant progress has been achieved here with deployment of the HAO Coronal Multichannel Polarimeter (CoMP). The instrument provides polarization measurements of Fe XIII 10747 A forbidden line emission. The observed polarization depends on magnetic field through the Hanle and Zeeman effects. However, because the coronal measurements are integrated over line-of-site (LOS), it is impossible to derive the configuration of the coronal magnetic field from a single observation (from a single viewing direction). The vector tomography techniques based on measurements from several viewing directions has the potential to resolve the 3D coronal magnetic field structure over LOS. Because of the non-linear character of the Hanle effect, the reconstruction result based on such data is not straightforward and depends on the particular coronal field configuration. Therefore, previously we also studied what is the sensitivity of the vector tomographic inversion to various coronal magnetic field models. For several possible cases of coronal magnetic field configuration, it has been found that even just Stokes-Q and -U data (supplied with 3D coronal density and temperature) can be used in vector tomography to provide a realistic 3D coronal magnetic field configuration. The 3D coronal density and temperature needed as an supplemental input are reconstructed by the scalar field tomography method using ultraviolet observations from EUVI/STEREO. We will present the reconstructed 3D coronal magnetic field in the range of $\sim 1.3 R_\odot$ obtained by the vector tomographic technique that has been applied to the CoMP data.

Lamb, D.

SWAMIS Emerging Flux Detection and Magnetic Feature Tracking for SDO

Co-Authors: C. E. DeForest

Affiliation of presenter: Southwest Research Institute, Boulder, CO

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength

Abstract:

At the previous SIP workshop we presented an overview of early stages of the Southwest Magnetic Identification Suite (SWAMIS) emerging flux detection code. The code is nearing completion and has been emitting "beta" events to the Heliophysics Event Knowledgebase for some time. We will report on the current state of the code (with some lessons learned along the way), give a brief overview of the algorithm, show some example emerging flux events, and finally show how to mine the Knowledgebase for Emerging Flux events. If time permits, we will also describe the current state of development of scientific SWAMIS, which will allow feature tracking of full-resolution HMI magnetograms.

Lopez, F. M.

Revealing structures and dynamic phenomena on ground-based coronagraph observations via a multi-resolution approach

Co-Authors: G. Stenborg; L. Balmaceda; C. Francile

Affiliation of presenter: Instituto de Ciencias Astronómicas, de la Tierra y del Espacio(ICATE)/CONICET

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength

Abstract:

Despite the wealth of space-borne observations of the white light solar corona, ground-based instrumentation has not been yet fully superseded. In particular, the so-called Mirror Coronagraph for Argentina (MICA) has now observed the inner corona (1.05 to 2.0 solar radii) over a whole solar cycle through a narrow band filter centered at 530.3 nm. Its high temporal cadence (1 min in average), relative high spatial resolution (~3.6 arc sec/pixel), proximity of its field-of-view to the solar limb free of vignetting effects, and the use of an specific emission line make it an excellent complement to existent space instrumentation. However, the high variability of the observing conditions at its location (San Juan, Argentina [69.3 W, 31.8 S], at 2400 m altitude) due mainly to atmospheric turbulence, sky brightness variability, and winds, proved to be a major obstacle to allow the full survey and proper analysis of the whole dataset. Only a handful of events have been analyzed to date. We intend to prove that, albeit the inherent constraints that are of common knowledge when observing the emission line corona from ground, we can still take advantage of the instrument to shed light into the kinematical properties of limb events (as observed in white light) during their early stages. In particular, we make use of a technique based on the a-trous wavelet transform to minimize the effects of the fluctuating atmospheric conditions and instrumental jittering while increasing the relative contrast of the dynamic features of interest. The algorithm can be applied straightforwardly on a broad spectrum of similar ground-based instruments. In this work, we introduce the algorithm and present a set of case studies from MICA's database, which provide different scenarios and hence, allow us to test the helpfulness of the technique. We expect this work to contribute to both scientific and educational aspects since it will open new opportunities for Astronomy undergrad students at the University of San Juan, Argentina, to carry out research projects in Solar Physics.

Martens, P.

Filament and Sigmoid Statistics Gathered by Newly Developed Automated Feature Finding Modules

Co-Authors:

Affiliation of presenter: Montana State University

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength; Solar Information processing techniques; Problem-solving session

Abstract:

We have used two automated feature finding modules developed by the SDO Feature Finding Team (FFT), namely the "Sigmoid Sniffer" and the "Advanced Automated Solar Filament Detection and Characterization Code", to study the statistics and correlations of these two phenomena from AIA and ground-based H-alpha observations. We find some familiar, some new, and some startling results. New, as far as we know, but expected, is the strong correlation between filament chirality and sigmoid handedness. Startling is that we have, so far, found no confirmation of the chirality hemispheric rule, and surprising is a double-humped distribution of the angle that filaments make with respect to the equator.

Oktem, S. F.

Multi-order slitless solar spectroscopy: a Parametric Inversion Approach

Co-Authors: F. Kamalabadi, J. M. Davila

Affiliation of presenter: University of Illinois at Urbana-Champaign

Working Groups: Solar Information processing techniques

Abstract:

Spectrographs provide measurements of emission line parameters, which are essential for extracting the plasma parameters and understanding the dynamic solar atmosphere. However, spectral observations of multiple spatial dimensions with inherently two-dimensional detectors pose intrinsic limitations on the spatio-temporal extent of the technique. A common observation strategy, based on conventional slit spectrographs, is to use a narrow field-of-view and a time-consuming rastering process, hence limiting the spectroscopic analysis of dynamic events. An alternative strategy is to use a slot spectrograph by widening the slit; however the dispersion within the wide slot image is the bottleneck. Recently the concept of multi-order slitless spectroscopy has been developed to address these limitations. Based on a parametric model for the formation of dispersed images, we study the problem of estimating emission line parameters from the slitless spectrometer measurements. This inverse problem can be viewed as a multiframe deblurring problem with shift-variant blur, where multiple blurred images of the same object are obtained through multiple spectrometer measurements, each with a different diffraction order. We approach the solution of this problem based on an iterative parametric inversion technique with regularization. The new deblurring method provides significantly more accurate intensity, Doppler shift, and line widths over a large spatial region on the Sun. We also perform sensitivity analysis using the Cramer-Rao framework, which yields insights about instrument optimization. The development of optimized multi-order slitless spectrographs and reliable inversion algorithms will yield reconstruction of spectral line parameters at every pixel over the large FOV, and faciliate the understanding of highly dynamic solar events such as flares, CMEs, and transient brightening.

Pesnell, W. D.

Tracking the Elusive Polar Coronal Hole

Co-Authors: S. Hess Webber , N. Karna

Affiliation of presenter: NASA-GSFC / George Mason University

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength

Abstract:

We present areas of the polar coronal holes calculated using three methods. These features are large at solar minimum and disappear at solar maximum. Difficulties of these calculations include projection effects near the poles and the need to watch over a rotation to detect the feature. We show how imprecision in coordinate assignments at the poles and limb of the solar disk adds to the uncertainty of these areas. Our results suggest that the two hemispheres have disparate minima and maxima during each cycle, showing that comparing the PCH areas between minima phases based on sunspot number is not correct. Based on our results, the northern PCH area began a declining trend in 2010, suggesting that the maximum of solar cycle 24 is already occurring in that hemisphere, while the southern hole remained large throughout 2010. Some historical data that can be analyzed using similar techniques will also be presented.

Pevtsov, A.

GPU based coronal loop detection algorithm and processing

Co-Authors: R. T. J. McAteer, J. Jackiewicz, B. McNamara

Affiliation of presenter: New Mexico State University

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength; Solar Information processing techniques

Abstract:

We study the spatial distribution and temporal evolution of coronal loops using data from the Solar Dynamics Observatory (SDO) Atmospheric Imaging Assembly (AIA). We apply an automated graphics processing unit (GPU) accelerated coronal loop detection algorithm to extreme ultraviolet images of the solar corona. The algorithm is maximized for accuracy and completeness; it detects complete and partial loops (orphaned segments) and attempts to reconnect these segments to create complete loops. We examine advantages and disadvantages of GPU acceleration from hardware and software while exploring how methods used in this automated detection process can be applied to different features across the solar corona.

Plowman, J.

Using DEM Algorithms for Coronal Data

Co-Authors:

Affiliation of presenter: Montana State University

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength; Reconstruction of the three-dimensional structure of the corona; Solar Information processing techniques; Accessing, browsing, retrieving data

Abstract:

We demonstrate the use of recently developed algorithms for fast inversion of Differential Emission Measures (DEMs) from solar coronal data. The algorithms are briefly described, instructions for their use are given, and their performance is analyzed. We also discuss Bayesian posterior reconstructions of DEMs (e.g., MCMC), and illustrate the extent to which DEM inversions, in general, can correctly recover the original input DEMs.

Salmon, J.

Poisson noise reduction with non-local PCA

Co-Authors: Z. Harmany, C.-A. Deledalle, R. Willett

Affiliation of presenter: Duke University

Working Groups: Solar Information processing techniques

Abstract:

Photon-limited imaging, which arises in applications such as spectral imaging, night vision, nuclear medicine, and astronomy, occurs when the number of photons collected by a sensor is small relative to the desired image resolution. Typically a Poisson distribution is used to model these observations, and the inherent heteroscedasticity of the data combined with standard noise removal methods yields significant artifacts. This paper introduces a novel denoising algorithm for photon-limited images which combines elements of dictionary learning and sparse representations for image patches. The method employs both an adaptation of Principal Component Analysis (PCA) for Poisson noise and recently developed sparsity regularized convex optimization algorithms for photon-limited images. A comprehensive empirical evaluation of the proposed method helps characterize the performance of this approach relative to other state-of-the-art denoising methods. The results reveal that, despite its simplicity, PCA-flavored denoising appears to be highly competitive in very low light regimes.

Stenborg, G.

Towards the Pseudo-Automatic Characterization of the Morphological and Kinematical Properties of Coronal Mass Ejections using a texture-based Technique

Co-Authors: C. R. Braga , A. Dal Lago (2)

Affiliation of presenter: George Mason University

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength; Solar Information processing techniques

Abstract:

The detection and tracking of coronal mass ejection (CME) events in white light images (e.g., from the SOHO/LASCO and STEREO/SECCHI coronagraphs, and/or STEREO/SECCHI heliospheric imagers) can be addressed as a bi-partitioning segmentation problem. Albeit differences on the pre-processing of the data, the mathematical property employed by the majority of the techniques actually in use is simply based on the different intensity level exhibited by the two sets (i.e., the CME feature and the background). Recently, it has been proved that the overall spatial relationship that the gray levels in the image have to one another (i.e., the image texture) can also be used as a discriminant to separate the coronal events from the background (Goussies et al., 2010). In their work, they represent the texture content of a given region by means of the so-called Gray Level Co-occurrence Matrix (GLCM), which is a matrix composed of the relative probabilities that two neighboring pixels separated by a certain distance ("d") have specific gray levels (namely, "i" and "j"), respectively (i.e., it contains the information about the distribution of the intensity levels inside the region). A bi-partitioning segmentation problem is commonly solved in computer vision via front evolution using levels sets. However, as proven in their work, the GLCM for the CME feature does not follow exactly a known probability density function. Therefore, direct applicability of proposed solutions in the literature were not possible. They introduced the idea of using an statistical test (i.e., a chi square test) to overcome the absence of a known probability density function and thus evaluate whether the two sets have the same distribution up to certain level of significance (i.e., to determine whether the GLCM of a given pixel "x", i.e., its texture, resembles that of the background -CME- or the foreground). Hence, they designed a supervised technique to detect and track coronal events by means of their texture on the coronagraph field of view and named it CORSET (CORonal SEgmentation Technique). We have now extended its capabilities by adding new routines to determined automatically several morphological and kinematical

parameters like angular width, direction of propagation, and speed to name a few. We tested the extended algorithm against a list of 57 well studied CME limb events as well as on a fair set of halo CMEs. In this presentation, we will briefly describe the mathematical procedure devised to pseudo-automatically detect and track CME events by means of their texture, and the algorithms we designed to determine their morphological and kinematical properties. A comparison of our results with those obtained by other methods (both fully manual, and fully automatic), namely from the CDAW and CACTUS catalogs, will also be presented.

Valluri, M.

Segmentation of Coronal Holes Using Active Contours and Detection of Small Boundary Flashes

Co-Authors: L. E. Boucheron, R. T. J. McAteer

Affiliation of presenter: Klipsch School of Electrical and Computer Engineering, New Mexico State University

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength; Solar Information processing techniques;

Abstract:

Coronal holes are regions of low-density plasma on the Sun with open magnetic field lines, and are the source of the fast solar wind. The detection and characterizing of these regions is important to both testing theories of their formation and evolution and from a space weather perspective. We present initial results of the application of active contours without edges for automated detection of coronal holes. We use full disk solar images from the Solar Dynamics Observatory (SDO) Atmospheric Imaging Assembly (AIA) at multiple wavelengths to test the proposed algorithm. The proposed method can detect coronal holes without dependence on a fixed threshold value, as used by many previous methods. Instead, the active contour segmentation employs an energy-minimization in which coronal holes are assumed to have more homogeneous intensities than surrounding active and quiet sun. The obtained segmented results are verified using magnetogram data and solar wind data. We also introduce an algorithm to detect small transient flashes occurring around the boundary of coronal holes and the co-occurrence of these flashes and the detected coronal hole boundary.

Vuiets, A.

Connectivity in oscillation processes observed in the solar Soft X-rays EUV irradiance during flaring events

Co-Authors:

Affiliation of presenter: CNES/LPC2E/University of Orleans

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength; Reconstruction of the three-dimensional structure of the corona; Solar Information processing techniques

Abstract:

In the last two years, there has been an unprecedented large number of missions observing the solar spectral irradiance in the Ultraviolet, with high time resolution: LYRA/PROBA2, PREMOS/PICARD and ESP/SDO. Some of these instruments offer cadences up to 20 Hz, which reveals a world of small-scale features. In this work we focus on pronounced oscillation phenomena (also known as quasi-periodic pulsations (QPPs)) which are observed coherently in the solar Soft X-rays (XUV) and Extreme-Ultraviolet (EUV) emissions during flaring events. The main question we address here is how these QPPs are connected across different layers of the solar atmosphere and what is the origin or driver that governs them. The traditional approach to this problem is a correlation analysis but this cannot adequately reveal causal relations. To overcome this ambiguity we consider an information-theoretic approach and estimate the Granger causality. The results reveals information flows between the different spectral bands, from which we infer the underlying physical properties.

Zharkov, S.

Principle Component Analysis of the solar background and sunspot magnetic fields in the cycle 21-23.

Co-Authors: V. V. Zharkova, S. J. Shepherd

Affiliation of presenter: Mullard Space Science Laboratory, University College London, UK

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength; Solar Information processing techniques; Problem-solving session

Abstract:

In this work we apply principle component analysis (PCA) to (a) the solar background magnetic field (SBMF) measured by the Wilcox Solar Observatory with low spatial resolution for solar cycles 21-23, and, (b) the sunspot magnetic field (SMF) in cycle 23 measured via automated sunspot detection algorithm applied to the whole set of SOHO/MDI observations. We present the first results of PCA analysis of SBMF and SMF with the principal components (PCs) in time and corresponding empirical orthogonal functions (EOFs) in latitude. We discuss the two main PCs derived for the period of 3 solar cycles and their implications for the solar activity in cycle 24. In addition, we discuss the 4 pairs of empirical orthogonal functions for SBMF in latitude assigned to either symmetric or asymmetric types of meridional flows. The results indicate the existence of dipole and quadruple magnetic structures in the SBMF. We also investigate how these PCs and EOFs affect the occurrence of sunspot magnetic field in time and latitude, as well as the magnetic tilts and charge separation of sunspot groups. We also discuss some preliminary results of sunspot tracking and sunspot group identification.

Poster Contributions

Al-Ghraibah, A.

Automated Classification of Flaring Behavior in Solar Active Regions

Co-Authors: L. Boucheron, R. T. J. McAteer

Affiliation of presenter: NMSU

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength; Solar Information processing techniques;

Abstract:

Solar active events are the source of many energetic and geo-effective events such as solar flares and coronal mass ejections. Understanding how these complex source regions evolve and produce these events is of fundamental importance, not only to solar physics but also to the demands of space weather forecasting. Here, we present work using physical properties of magnetic region complexity for an automated classification of future flare activity. First, we extract features related to physical properties of active region magnetic fields including fractal-, gradient-, neutral line-, emerging flux-, and wavelet-based techniques. Second, we use automated classifiers to predict whether an active region will flare in the following Y hours, where Y will vary. Third, we apply feature selection to extract the most significant features for flare prediction and improve the classification speed and accuracy. This work gives a preliminary assessment of the use of feature extraction, feature selection, and classification for flare prediction as well as to lend insight into the physical characteristics of active regions that are most discriminatory for such a prediction task.

Banda, J.

Compressing SDO's FITS image files, a study from an image-processing perspective

Co-Authors: R. A. Angryk, P. C. Martens

Affiliation of presenter: Montana State University

Working Groups: Solar Information processing techniques; Accessing, browsing, retrieving data

Abstract:

In this work, we will discuss the benefits of image compression for processing of images from enormous SDO repository. With the objective of making solar image files more portable and easy to distribute and archive, we will test several lossless compression algorithms as well as many other lossy compression algorithms in order to determine how much (if at all) we can compress the standard FITS solar image files and still produce equal or comparable results. By looking at solar FITS images purely from an image-processing viewpoint, we want to determine if we can use modern compression algorithms to reduce storage costs and analysis time by dealing with smaller sized images. We believe that we might be able to hold huge repositories such as the SDO repository in a considerably smaller amount of disk space and still be able to perform the same image analysis experiments on this reduced and more portable repository.

Davey, A.

How SDO Changed Solar Physics?

Co-Authors:

Affiliation of presenter: Harvard Smithsonian Center for Astrophysics

Working Groups: Accessing, browsing, retrieving data

Abstract:

The advent of a new mission brings new datasets and hopefully new discoveries that change the scientific landscape. The Solar Dynamics Observatory (SDO) mission, and its instrument suite, the Atmospheric Imaging Assembly (AIA), the Extreme ultraviolet Variability Explorer (EVE) and the Helioseismic and Magnetic Imager (HMI), is the latest mission to do that for solar physics. SDO's influence has been felt far beyond just the scientific.
SDO has provided large challenges in the areas of data storage, data distribution and access, and also data analysis. The data storage requirements for this mission far exceed that of all other solar physics space missions combined. This provides major challenges in getting the data into the hands of solar physicists in the US and around the world.

Given the massive data volumes, new approaches to finding data of interest were required. NASA funded a project to build computer vision tools that would automatically analyze data from the spacecraft, feeding LMSAL's Heliophysics Event Knowledgebase (HEK) with features and events. In this way solar physicists have a new vector into finding data for research projects.

This poster discusses the ways in which the challenges of a large scale mission such as SDO have been met, particularly the changes in the way the solar physics community approaches data access and analysis, and what this might mean for future large missions such as ATST.

DeForest, C.

Quantitative Heliospheric Imaging: how to separate 99.9% of your data (and have something left).

Co-Authors: T.A. Howard

Affiliation of presenter: Southwest Research Institute

Working Groups: Solar Information processing techniques

Abstract:

Heliospheric imaging uses similar technology to coronagraphy, but with different geometry. Both coronagraphs and heliospheric imagers are sensitive to Thomson scattered sunlight from free electrons in the solar atmosphere and wind. In the wide-field heliospheric imaging case, the Thomson scattering signal is three orders of magnitude fainter than the background from the galaxy and Zodiacal light, yet it is possible to extract meaningful quantitative information about solar wind evolution and structure from these data. We present our novel extraction techniques for separating the signal from background; some early results including a measure of the flux disconnection rate that sets the equilibrium value of the interplanetary magnetic field; and some current work on the importance of polarized heliospheric imaging for understanding structures in three dimensions.

Engell, A.

Polarity Inversion Line Module

Co-Authors: P. C. Martens, R. Timmons

Affiliation of presenter: MSU

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength; Accessing, browsing, retrieving data

Abstract:

The polarity inversion line (PIL) module is complete and running at LMSAL. Near real time save files that are created from the module will be retrieved by Montana State University and will be made publicly available online linked through the Feature Finding Team's website and the Heliophysics Event Knowledge base website. Within the save files are the PIL locations, potential transverse field gradients, photospheric magnetic field gradients, and active region bounding boxes with corresponding AR numbers as determined by the Stanford HARPs program. The PIL code will be made publicly available as well as a code for reading in the save files and put them on solar data (HMI, AIA, etc). They will be on the same website as the save files. Beyond this, full disk images and image cutouts as determined by HARP AR are also available online for context and visualization.

Felix, S.

Applying Computer Vision to SDO/AIA images

Co-Authors: A. Csillaghy

Affiliation of presenter: University of Applied Sciences North Western Switzerland

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength; Reconstruction of the three-dimensional structure of the corona; Solar Information processing techniques

Abstract:

Many feature recognition techniques used in solar information processing are based on a priori information. Observations are checked against a specific, physical model. But what about trying to inspect images in a fully agnostic way? As such an approach, which has been less investigated, Computer Vision algorithms can come into play. Computer Vision algorithms mimic the abilities of human vision. These algorithms are used for a variety of applications: A prominent example is the search for similar images offered by Google, but other applications like object recognition and image stitching often also rely on Computer Vision. Solar physics could take advantage of those algorithms. To this end, we have set up a prototype content based image retrieval system (CBIR) which uses the SIFT (scale-invariant feature transform) algorithm on SDO/AIA images. SIFT locates interesting points in the images. These points get grouped into visual words that describe specific local characteristics of the image region. Based on these visual words, our system then attempts to locate images that feature similar words, much in the same way that conventional text information retrieval systems work. Our poster will show our first results, an evaluation, and the future in this approach.

Gyori, L.

Automatic finding, tracking, and analysing sunspots and white light faculae

Co-Authors:

Affiliation of presenter: Debrecen Heliophysical Observatory

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength

Abstract:

The shear volume of the solar images provided by the ground-based and the space-borne observatories makes unavoidable to automate the detection, tracing, and analysis of the solar features. In this presentation, we show a possible solution of these problems for sunspots and white light faculae. Detection. To find sunspots and white light faculae the a solar image is decomposed into cross sections at intensities determined by the image statistics. Each intensity cross section is broken down into connected pixels domains. To every local extremum (in this context it is a domain not containing other domains) a set of the domains are assigned, namely those ones that contain the extremum. The assignment is done in an ordered way, the ordering relation is induced by the containment relation between two domains. This system well represents the inner structure of a feature and also the the structural relations between features. Combining the connected pixels domains, ordered into local extrema, with the gradient image, the domains representing the features can be determined. Tracking. Mapping the feature domains of an image into an other image (supposing that the time characterizing the evolution of the feature is longer than the time between two images) induces relations (set relations) between the features of the two images. A relation (i.e., the intersection relation) generates a graph of sunspots. The vertices of the graph are the individual features of the individual images. To every vertex the properties of the corresponding feature are attached. The edges of the graph are determined by the related features. Analysis. Traversing the spot graph the motion and evolution of the spots can be revealed as it is exemplified by the spots of the solar images taken around the X5.4 fear of 7 March 2012 00:28 UT.

Harker, B.

Polarization Fringe Removal Using Wavelet Analysis

Co-Authors:

Affiliation of presenter: National Solar Observatory

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength; Solar Information processing techniques

Abstract:

Thin-film interference at the entrance and exit windows of a ferroelectric liquid crystal (FLC) polarization modulation train can give rise to periodic intensity variations (interference fringes) in the recorded spectra and/or images. This poster explores the removal of such artifacts from the polarization spectra recorded by the Synoptic Optical Long-term Investigations of the Sun (SOLIS) Vector Spectromagnetograph (VSM), using a Morlet wavelet analysis developed by Rojo & Harrington (2006).

Hill, S.

Automated and Interactive Image Analysis at NOAA's Space Weather Prediction Center

Co-Authors:

Affiliation of presenter: NOAA/SWPC

Working Groups:

Abstract:

NOAA's Space Weather Prediction Center (SWPC) is the Nation's official source of space weather alerts, watches and warnings. In that role, the Center ingests both NOAA and non-NOAA sources of solar imagery that our forecasters use to inform their analysis (nowcast) and forecasts and also as sources of data to run empirical and numerical models. This presentation provides an overview of operational and development activities at SWPC in the area of automated and interactive solar image analysis. The GOES-R satellite series will carry a Solar Ultraviolet Imager (SUVI) – something of a little brother to the Solar Dynamics Observer (SDO) Atmospheric Imaging Array (AIA). A supervised, multispectral, Bayesian pixel classifier has been developed and produces what are referred to as thematic maps. The maps represent classes of pixels including: space, coronal holes, quiet corona, filaments, active regions, and flares. The thematic maps are currently undergoing operational test and evaluation at SWPC using AIA synoptic data in near real time as a proxy for SUVI data. In addition, SWPC forecasters are examining the outputs from the CHARM (Coronal Hole Automated Recognition and Monitoring) model, which uses local intensity thresholding techniques. Finally, SWPC is also in the process of migrating much of its forecast operations systems to the NWS enterprise system known as AWIPS 2 (Advance Weather Interactive Processing System 2). AWIPS 2 brings the full power of GIS and mapping systems used for terrestrial weather analysis and forecast to the solar domain. This presentation reviews these image analysis efforts at SWPC.

Hughitt, V.

SunPy: Python for Solar Physics Data Analysis

Co-Authors: S. Christe, J. Ireland, F. Mayer; D. Perez-Suarez, A. Shih, M. D. Earnshaw, C. Young, R. Schwartz.

Affiliation of presenter: NASA GSFC/ADNET SYSTEMS

Working Groups: Solar Information processing techniques; Accessing, browsing, retrieving data

Abstract:

Python has seen widespread adoption among the scientific community in recent years resulting in a wide range of software being written for everything from numerical computation and machine learning to spectral analysis and visualization. SunPy is a free and open-source software library for working with solar and heliospheric datasets, written in the Python programming language. It provides an alternative to the IDL-based SolarSoft (SSW) solar data analysis environment.

SunPy has map objects that allow simple overplotting of data from multiple two-dimensional image FITS files; time-series objects that allow overplotting of multiple lightcurves, and initial support for working with spectrogram data. SunPy provides integration with online services such as The Virtual Solar Observatory (VSO), The Heliophysics Event Knowledgebase (HEK), and Helioviewer.org. SunPy also provides functionality that is not currently available in SSW such as advanced time series manipulation routines and support for working with solar data stored using JPEG 2000. We give some examples of what can be done in SunPy, and show how Python-based solar data-analysis can take advantage of many different data analysis tools not readily available in SSWIDL.

We also discuss future goals for the project and ways for interested users can become involved in the planning and development of SunPy.

Ireland, J.

Extending the usage of the Helioviewer Project

Co-Authors: V. K. Hughitt, B Mueller

Affiliation of presenter: ADNET Systems at NASA GSFC, Maryland, USA

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength; Reconstruction of the three-dimensional structure of the corona; Solar Information processing techniques ; Accessing, browsing, retrieving data; Problem-solving session

Abstract:

The Helioviewer Project has enabled thousands of users to explore the inner heliosphere, providing access to over ten million images from the SOHO, SDO, and STEREO missions. Users can explore solar image archives, create movies on the fly, and interact with other solar and heliospheric services like the SDO cut-out service and the Virtual Solar Observatory (VSO). In addition to providing a powerful platform for browsing heterogeneous sets of solar data, the Helioviewer Project seeks to be as flexible and extensible as possible, providing access to much its functionality via a simple Application Programming Interface (API). The API can be used to create images and movies from data available on Helioviewer.org, or to embed a simplified version of Helioviewer.org into another website. Recently the Helioviewer.org API was used for four such applications developed by outside interests: an SDO data browser, a space situational awareness browser, a public education website, and a Python library for solar physics data analysis (SunPy). These applications are discussed as examples of Helioviewer API usage.

Finally, we introduce a recently added ability to Helioviewer.org. The website now generates Solarsoft/IDL and SunPy script snippets that describe VSO queries to the full science quality data corresponding to the movies generated in Helioviewer.org. When these scripts are pasted into a Solarsoft/IDL or SunPy session, the science data is downloaded to the user's computer. This allows Helioviewer.org users to easily acquire the science data behind the visualization provided by Helioviewer.org. Further extensions to the Helioviewer Project are also discussed. The Helioviewer Project is supported by ESA and NASA.

Jeska, L.

Analysis of SDO Data for propagation of waves and other features using a graphical user interface based IDL package

Co-Authors:

Affiliation of presenter: Aberystwyth University

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength; Solar Information processing techniques; Accessing, browsing, retrieving data

Abstract:

Data from the Solar Dynamics Observatory have the potential to reveal new information on wave propagation in the solar corona. Working at the limits of optical resolution, and looking for tiny fluctuations compared to the signal size, means that the choice between different image re-normalization tactics, or the use of various image difference techniques, is critical to enhance the desired features. I will demonstrate a GUI-based IDL package that facilitates the trial use of many different techniques, and at many different image locations. The package will be used to show the analysis of a large eruption event on 7th March 2011, in which waves can be seen propagating around the solar limb and across the solar disc. The subroutines developed also have the potential to allow a larger-scale automated approach to data analysis.

Kraaikamp, E.

Dimming and EIT wave detection on SDO/AIA: first results by NEMO

Co-Authors: C. Verbeeck, O. Podladchikova, the AFFECTS team

Affiliation of presenter: Royal Observatory of Belgium, Belgium

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength; Solar Information processing techniques; Accessing, browsing, retrieving data

Abstract:

Dimmings and EIT waves have been observed routinely in EUV images since 1996. They are closely associated with coronal mass ejections (CMEs), and therefore provide useful information for early space weather alerts. On the one hand, automatic detection and characterization of dimmings and EIT waves can be used to gain better understanding of the underlying physical mechanisms. On the other hand, every dimming and EIT wave provides extra information on the associated front side CME, yielding improved estimates of the geo-effectiveness and arrival time of the CME.

The Novel EIT wave Machine Observation code (NEMO) was initially developed to automatically detect and analyze EIT waves and dimmings using images provided by the SOHO Extreme-ultraviolet Imaging Telescope (SOHO/EIT). In the context of the Early Warning System of the AFFECTS FP7 project, the algorithm is currently being adapted at the Royal Observatory of Belgium to run in near real time on Solar Dynamics Observatory/Atmospheric Imaging Assembly (SDO/AIA) data.

On this poster we provide the details of the algorithm and present an overview of the first NEMO results on a few selected events as observed by SDO/AIA.

Pérez-Suárez, D.

HELIO - All the heliosphere in your hands

Co-Authors: HELIO consortium team

Affiliation of presenter: Trinity College Dublin / HELIO consortium team

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength; Solar Information processing techniques; Accessing, browsing, retrieving data; Problem-solving session

Abstract:

HELIO, the HELiophysics Integrated Observatory, is a new tool currently being developed by an international consortium under the European Commission's Seventh Framework Programme (FP7) which will help you to discover heliophysics data in a simple way. This is being achieved by merging features and events catalogues, data archives and, processing tools which will allow the users, besides to find all the data available that have observed a certain event while propagate through the whole solar system, to create their own workflows.

HELIO definitely will make the research in heliophysics more accessible to different scientists. But it capabilities goes further than this, and it could be adapted to other fields in science where multiple observations in different observatories are used to study a particular event.

This talk will consist on a brief introduction of what HELIO is and a detailed user case demonstration joining events at different points in the heliosphere.

Pérez-Suárez, D.

The Coronal Pulse Identification and Tracking Algorithm (CorPITA) for automated detection of "EIT Waves"

Co-Authors: D. M. Long, D. S. Bloomfield, R. Feeney-Barry, P. T. Gallagher

Affiliation of presenter: Trinity College Dublin / HELIO consortium team

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength.

Abstract:

The Coronal Pulse Identification and Tracking Algorithm (CorPITA) is an automated algorithm for detecting and analysing "EIT Waves" in data from the Solar Dynamics Observatory (SDO) spacecraft. CorPITA will operate as the automated coronal pulse detection system for the Heliophysics Event Knowledgebase (HEK), providing near-real-time identification of coronal pulses. When triggered by the start of a solar flare, the algorithm uses an intensity profile technique radiating from the source of the flare to examine the entire solar disk. If a pulse is identified, the kinematics and morphological variation of the pulse are determined for all directions along the solar surface. CorPITA has been applied here to a series of solar flares of different classes from 13-20 February 2011. This allows a systematic characterisation of the effectiveness of the algorithm and the morphology of the different eruptions studied. The automated nature of this approach will enable an unbiased examination of "EIT Waves" and their relationship to coronal mass ejections, and as a result has implications for space-weather forecasting.

Sattelberger, J.

The Virtual Solar Observatory

Co-Authors:

Affiliation of presenter:

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength; Solar Information processing techniques; Accessing, browsing, retrieving data; Problem-solving session

Abstract:

The Virtual Solar Observatory is the oldest of the heliophysics virtual observatories. As such it has laid the groundwork for many of the other virtual observatories in the heliophysics realm. It was set up to respond to the tasks detailed below and continues to be driven by them. This poster outlines how we achieve these tasks today and going forward.

- Provide homogenous access to heterogeneous solar physics data in the process providing scientists the data they needed to do research while hiding the nuts and bolts of where that data was and how they got it.
- Enable scientists to search and filter meta-data, minimizing the amount of data that needed to be downloaded.
- Provide scientists access to data they may not be aware of, or data complimentary to their primary datasets.
- Provide means for scientists to share their data and assistance in making it available and usable to the community.
- Provide access to data for other projects such as data visualization and other search systems.
- Provide a clearinghouse of information for researchers on how to find and use solar physics data and tools, including those not directly provided by the VSO.
- Represent the solar physics community on broader standardization efforts.
- Be responsive to the solar physics community's needs.

Schuh, M.

Evaluating Automated Solar Event Detection

Co-Authors: J. Banda, R. Angryk, P. Martens

Affiliation of presenter: Montana State University

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength; Solar Information processing techniques; Accessing, browsing, retrieving data

Abstract:

We build upon our existing framework for comparative evaluation by introducing additional analysis and verification methods that provide more comprehensive results and a better understanding of solar event detection and automated module effectiveness. Our prior investigation of the Advanced Automated Filament Detection and Characterization Code (AAFDCC) module on Hα images is revisited before shifting our current focus to images from the new Solar Dynamics Observatory (SDO) and automated events reported to the publicly available Heliophysics Event Knowledgebase (HEK) repository. This work was supported in part by two NASA Grant Awards: 1) No. NNX09AB03G, funded from NNH08ZDA001N-SDOSC solicitation, and 2) No. NNX11AM13A, funded from NNH11ZHA003C solicitation.

Stenborg, G.

On the use of the Dual Tree Complex Wavelet Transform on white light coronal images

Co-Authors: A. Pagamisse, O. Mendes Junior, M. Oliveira Domingues

Affiliation of presenter: George Mason University

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength; Solar Information processing techniques

Abstract:

Dynamic coronal events, e.g., coronal mass ejections (CME), observed in white light coronagraph images display a myriad of morphologies. Their morphological classification is therefore difficult and troublesome. The lack of a proper classification makes the determination of their kinematical properties even more subjective. The first step towards an unambiguous morphological classification is to find a mathematical property that can unambiguously characterize the coronal features of interest. Noise minimization and enhancement of the relative contrast of the feature are of utmost importance toward this goal. In this project, we introduce the dual-tree complex wavelet transform (DTCWT), aimed at selectively contrast-enhancing the CME events as observed with the LASCO/SOHO coronagraphs as a first stage to achieve an objective classification of coronal events. The properties of the DTCWT, e.g., directional selectivity (six directions) and translation invariance, along with its short computational time make it a promising tool for this task. The multilevel decomposition of an image with the DTCWT generates complex wavelet coefficients, which manipulated conveniently provide an improvement on the visualization of the plasma structures while attenuating the noise, and hence helping further analyses of the data. Several examples will be presented.

Stenning, D.

Automatic Classification and Tracking of Solar Features

Co-Authors: V. Kashyap, T. C. M. Lee, D. A. van Dyk, C. A. Young

Affiliation of presenter: Department of Statistics, University of California, Irvine

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength; Solar Information processing techniques; Accessing, browsing, retrieving data

Abstract:

The morphology of magnetically active regions associated with sunspot groups is predictive of both their future evolution and of explosive solar activity. The common practice of identifying and classifying sunspot groups by eye introduces bias stemming from the artificial and subjective nature of the discrete categorization. Furthermore, manual classification is impractical for the massive high-cadence datasets coming from current solar observatories. Using mathematical morphology, we extract science-driven numerical features from magnetogram and white light images of sunspot groups that are relevant to their classification. In addition to their use as input variables in statistical learning algorithms, numerical features will allow us to better describe the continuum of sunspot group/active region morphology. Our ultimate goal is to capture the evolutionary pattern of sunspot groups that are useful for predicting volatile solar events, such as solar flares and coronal mass ejections.

Timmons, R.

Heliophysics Event Knowledgebase for the Solar Dynamics Observatory and Beyond

Co-Authors: N. Hurlburt, M. Cheung, C. Schrijver, L. Chang, S. Freeland, S. Green, C. Heck, A. Jaffey, A. Kobashi, D. Schiff, J. Serafin, R. Seguin, G. Slater, A. Somani,

Affiliation of presenter: Lockheed Martin

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength; Solar Information processing techniques; Accessing, browsing, retrieving data

Abstract:

The immense volume of data generated by the suite of instruments on the Solar Dynamics Observatory (SDO) requires new tools for efficiently identifying and accessing data that is most relevant for research. We have developed the Heliophysics Events Knowledgebase (HEK) to fill this need. The HEK system combines automated data mining using feature-detection methods and high-performance visualization systems for data markup. In addition, web services and clients are provided for searching the resulting metadata, reviewing results, and accessing the data. We review these components and present examples of their use with SDO data, as well as extensions planned to support future missions and additional data sources.

Yoshimura, K.

Calibration of Hinode/XRT for Coalignment

Co-Authors: D. E. McKenzie

Affiliation of presenter: Department of Physics, Montana State University

Working Groups: Tracking solar features and eruptive events in space, time, and wavelength; Solar Information processing techniques

Abstract:

While it is important to coalign the solar images from different instruments, it is often difficult to achieve sufficient accuracy with a simple method. The final goal of our project is to provide an easy and precise coalignment method to users of the XRT data.

For the coalignment, we need to know the plate scales, rotation angle in the plane of the sky, and pointing information for the images, at least. To augment the information provided by the Hinode/XRT FITS headers, we are calibrating the XRT data as accurately as possible by means of limb fitting and cross correlation techniques, yielding a table of coalignment parameters for every single XRT image.

We also do a cross calibration between XRT, HMI, and AIA. By applying a local correlation tracking method to the pairs of the images from the instruments, we can improve the accuracy of the coalignment. Our parameter tables will include the results from the cross calibration too.

Zharkov, S.

Feature Recognition in Heliophysics Integrated Observatory

Co-Authors: D.Perez-Suarez, X.Bonnin, N.Fuller, P.Gallagher, J.Aboudarham, R.Bentley

Affiliation of presenter: MSSL/UCL

Working Groups: Solar Information processing techniques;Accessing, browsing, retrieving data

Abstract:

HELIO, the Heliophysics Integrated Observatory, is a research infrastructure funded under Capacities programme of the EC's 7th Framework Programme (FP7). It provides a collaborative environment where scientists can discover, understand and model the connection between solar phenomena, interplanetary disturbances and their effects on the planets. The project is designed around a service-oriented architecture with needed capabilities that support metadata curation and search, data location and retrieval, and data processing and storage being established as independent services.

HELIO provides integrated access to the data and metadata from the domains that constitute heliophysics - solar, heliospheric, geophysics and planetary. More than 50 event catalogues can be used in the search, together with just under 10 feature catalogues; data from more than 150 instruments from nearly 50 observatories can be accessed. A comprehensive user interface is available and the serves can also be accessed through IDL; a workflow tool provides the ability to combine services together and it is possible to execute programmes on demand including propagation models.

One of primary services is the HELIO Feature Catalogue (HFC) which provides access to a complete catalogue of automatically detected features in the heliosphere. The detection algorithms are not only used to populate the HFC, but form part of the service allowing users to run jobs on different data or with different parameters on the grid computing facilities provided by Grid-Ireland (www.grid.ie).

We will report on the status of HELIO feature recognition services that are available and demonstrate how these resources can be used to address use cases involving multiple spacecraft and modelling. We will also describe how we hope to combine the tools developed by HELIO into a Collaborative Research Environment for Heliophysics.

The HELIO Consortium includes thirteen groups from the UK, France, Ireland, Italy, Switzerland, Spain and the US; the project started in June 2009 and has a duration of 42 months

List of participants

Last Name	First Name	Affiliation
Al-Ghraibah	Amani	NMSU
Aschwanden	Markus J.	LMSAL
Banda	Juan	MSU
Boucheron	Laura	MSU
Byrne	Jason	Hawaii
Cabello García	Iballa Beatriz	U. de Valencia (España)
Cramer	Alexander	UMD
Csillaghy	André	NW Switzerland
Darnel	Jonathan	CIRES
Davey	Alisdair	CFA
De Visscher	Ruben	ROB
DeForest	Craig	SWRI
Delouille	Veronique	ROB
Engell	Alexander	MSU
Felix	Simon	Swiss
Feng	Li	Purple Mountain Obs, China
Frazin	Richard	U. Michigan
Ganesan Pillai	Karthik	MSU
Gencaga	Deniz	University of Texas at Dallas
Gyori	Lajos	Debrecen
Harker	Brian	NSO
Hero	Alfred	U. Michigan
Hewett	Russell	MIT
Hill	Steven	NOAA/SWPC
Hughitt	Vincent	GSFC
Ireland	Jack	GSFC
Jeska	Lauren	Aberystwyth U.
Kirk	Michael	New Mexico State U.
Kraaikamp	Emil	ROB
Kramar	Maxim	Catholic U. America
Lamb	Derek	SWRI
Lopez	Fernando Marcelo	Inst. de Ciencias Astronómicas, de la Tierra y del Espacio (ICATE)/ CONICET
McInerney	Patrick	Montana State University Computer Science

Last Name	First Name	Affiliation
Manley	Lawrence	*(none given)*
Martens	Petrus	MSU
Mierla	Marilena	ROB
Oktem	Sevinc Figen	U. Ilinois
Perez-Suarez	David	TCD
Pesnell	W. Dean	GSFC
Pevtsov	Alexander	NMSU
Plowman	Joseph	MSU
Podlipnik	Borut	Max Planck Inst.
Reardon	Kevin	NSO
Salmon	Joseph	Duke
Sattelberger	Jonathan	Harvard
Schuh	Michael	MSU
Scott	Jason	MSU
Sitongia	Leonard	NCAR, Boulder
Stenborg	Guillermo	NRL
Stenning	David	Harvard
Suarez Sola	Igor	NSO
Takeda	Aki	Department of Physics, Montana State
Thompson	Barbara	GSFC
Timmons	Ryan	LMSAL
Valluri	Meghala	New Mexico State U.
Vuiets	Anatolii	U. Orleans
Watson	Fraser	NSO/ Glasgow
Wylie	Tim	MSU
Yoshimura	Keiji	MSU
Young	C. Alex	NASA GSFC

Local and venue information for participants

Registration and presentation information

1. The **main meeting room is Reid Hall, Room 108, Engineering and Physical Sciences (EPS) Building**, at Montana State University main campus. Please see the campus map in the "Local Information" section below.
2. Registration is at the entrance to the main meeting room from 8:30 am first day (Monday 13th) of the meeting. Registrants can pay with credit cards, will receive receipts, conference dinner and reception tickets, name badges, plus Yellowstone tickets. For those to be reimbursed, please bring copies of your airline and boarding tickets, plus receipts. Those that have cars will be issued MSU parking permits
3. Invited talks: 35 minutes + 5 minutes questions and speaker changeover.
4. Contributed talks: 15 minutes + 5 minutes questions and speaker changeover.
5. Presenters giving talks are expected to use their own computer to give their talk. Please contact either the Science Organizing Committee or the Local Organizing Committee if you require assistance with your presentation in any way.
6. Poster presentations: maximum size available is 48 inches wide by 60 inches tall.

Schedule and Abstract information

1. Printed copies of the schedule and abstracts will NOT be available at the conference venue. Please print out your own copy of the schedule and the abstracts if you want your own paper copy.
2. The full, up-to-date meeting schedule will be available OUTSIDE the main meeting room for the entire meeting.
3. The schedule and abstract information will be updated online if necessary - see http://www.sipwork.org/sipwork-vi-final-announcement/ .

Venue information

1. The main meeting room is Reid Hall, room 108: http://www.facilities.montana.edu/pdc/projects/allPrjs/ReidHallRoom108/. Coffee and tea will be served there. This room will also hold the poster session.
2. Working group sessions will be held in various rooms close to the Reid Hall
3. Free wi-fi is available all across the MSU campus, including all the rooms used by the Workshop. A password is not required to use this wi-fi service.

Welcoming Reception (Monday 13th August, 6pm)

Monday night in the Alumni Room in the Strand Union Building on campus. Please see the campus map indicated in "Local Information" below.

Conference Dinner (Wednesday 15th August, 6-11pm)

1. The conference dinner will be at on Wednesday night, from 6 - 11pm at the Emerson Center (http://www.theemerson.org/). The center will have its art galleries open until 8 pm for our event. The Emerson is a pleasant 15 minute walk from campus, so no transportation to the event will be provided. The shuttle bus will be available at 11 pm to take participants to the meeting hotel. There will be a Montana style buffet, including sumptuous desserts, a cash bar, plus (TBC) beer and whiskey tasting. Live music for dancing will be provided by our homegrown Cajun band, Bebe Leboeuf: http://bebeleboeuf.com/home.shtm.
2. Please let us know if you have any dietary requirements.

Jazz Concert (Thursday 16th August, 7.30pm)

Free celestial-themed jazz concert at the Reynolds Recital Hall on MSU Campus with Jeni Fleming (http://www.montanapbs.org/11thGrantwithEricFunk/episode101/).

Yellowstone Excursion (Friday 17th August, after the Workshop)

1. Leave from the conference hotel at 7:00 am (hotel breakfast starts at 6am). Lunchboxes and drinks (in coolers) come on the bus and are included in the price. Tour group can stop at some gorgeous picnic area in the park. Dinner at the Pine Creek Cafe & Lodge on the way home, eclectic menu and live music: http://www.pinecreeklodgemontana.com/entertainment. Estimated arrival back at the hotel is 9pm.
2. Please let us know if you have any dietary requirements.

Local information

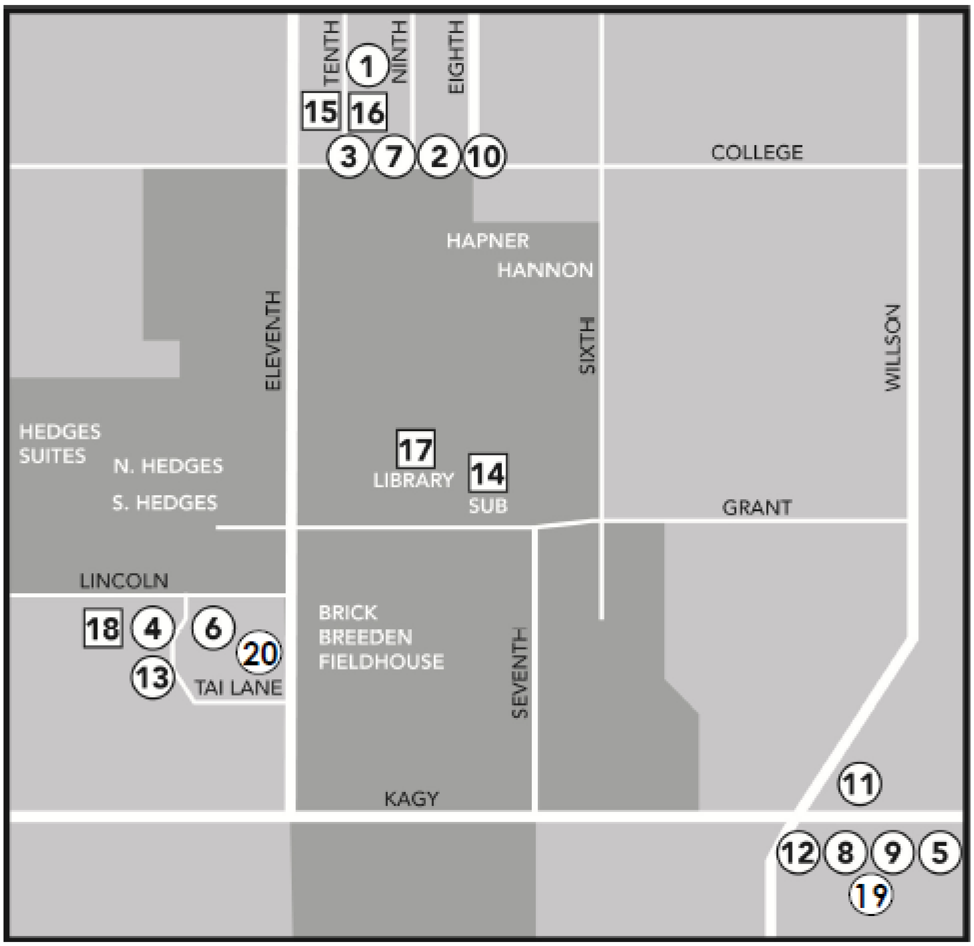
1. **Transportation to and from the airport.**
    a. For those staying at the conference hotel (Holiday Inn Bozeman), there is a **free shuttle bus** from the airport to the hotel. Please **call the hotel** (406 587-4561) to arrange a pick up.
    b. Taxi: Valley Cab, 406-388-9999, the only company in town. Trip from airport to the conference hotel is about $ 40,Taxis are available at the airport.
    c. Cars can be rented at the airport. This is also the best option if you wish to do some hiking around Bozeman in the evenings.
2. **Transportation around Bozeman**
    a. Bozeman has a free downtown bus. Information is available at http://www.streamlinebus.com/. A map of the route is available at http://www.streamlinebus.com/wp-content/uploads/2011/08/mainmap_7-13-11_2.pdf and the schedules can be found at http://www.streamlinebus.com/routes-schedulesweekday-serviceweekday-service/weekday-service/.
    b. If you are staying at the conference hotel (Holiday Inn Bozeman) and do not have a car, then we recommend that you take the **Blue Line from Oak St at Aspen Meadows, leaving at 8.17am to the MSU SUB.**

c. The **last Streamline Blue Line Bus** leaves MSU SUB at 5:36pm, and arrives at Oak St and Days Inn via the downtown part of Bozeman, at 5:58pm. It is a 10 - 15 minute walk from the conference venue to downtown Bozeman. Downtown Bozeman (Main Street) is the main restaurant location in Bozeman. **A bus from Main Street to the conference hotel will be provided, leaving at 9pm from outside the Baxter hotel on Main Street at 9 pm on Monday, Tuesday, and Thursday.**
d. Taxis are also available: call Valley Cab 406-388-9999.

4. **Bozeman and Montana State University**
    a. For MSU Campus maps, directions, etc, see http://www.montana.edu/campusmap/ and http://www.montana.edu/about/bozeman/. Bank, post office, ATM's, cafeteria, espresso shop, smoothies, MSU book store, MSU T-shirts, etc. are all to be found at the Strand Union Building (SUB), at the heart of campus, less than one minute from the main meeting room, Reid Hall.
    b. There is free wi-fi all over campus. A password is *not* required.
    c. For information on Bozeman downtown dining, bars, music and other info, go to http://www.downtownbozeman.org/#. The most pleasant way to find something to your liking is simply to stroll along downtown Main Street.
    d. Safety: Bozeman and Montana in general have an extremely low crime rate compared to the US average and to most European countries. The largest risk is drunk drivers at night and visiting wildlife. Women are advised to walk in groups in remote locations late at night. The police are helpful and friendly, as are locals. There is a cell phone ban for drivers in town.
    e. We highly recommend a visit to the Museum of the Rockies, a ten minute walk from campus. One of the best dinosaur collections in the US, plus a Native American and a pioneer section. Group tickets will be provided (TBC). The museum is open until 8 pm during the summer: http://www.museumoftherockies.org/Home.aspx
    f. This Google map - https://maps.google.com/maps/ms?msid=213779118566634207513.0004c594b019e87c5f6ce&msa=0&ll=45.686996,-111.038818&spn=0.743491,1.204376 -
    shows the conference hotel, the conference venue, bus stops and other places of relevance to SIPWork VI.

MSU area restaurant guide

MSU Area Restaurant Guide



① Casa Sanchez (closed 6/1/12)

719 S. 9th Ave
(406) 586-4516
Location: 5 min. walk north of the SUB and tucked behind Joe's Parkway on 9th Ave.
Style of food: Mexican/Southwest with table service
Hours: closed Sundays and Mondays
Tuesday-Saturday 5:00pm-9:00pm

② College Street Café and Grille

815 W. College
(406) 587-2693
Location: 5 minute walk north of the SUB just off the intersection 8th and College St.
Style of food: Breakfast, salads, sandwiches, burgers with table service
Hours: Tuesday-Sunday 7am-2pm

③ Columbo's Pizza & Pasta

1003 W. College St
(406)-587-5544
Location: 5 min. walk north of the SUB near the intersection of 11th and College St
Style of food: pizzas, pasta and salad bar with counter service
Hours: 11:00am-10:00pm

④ Storm Castle Cafe

5 Tai Lane
(406) 586-0395
Location: 7 min. walk southwest of the SUB just off the intersection of Lincoln St. and Tai Lane.
Style of food: Breakfast, Burgers, Shakes and Malts
Hours: 7:00am-2:00pm

(5) Food For Thought
270 W. Kagy
(406) 587-4454
Location: 10 min. walk south of campus, on corner of Wilson and Kagy.
Style of food: Specialty Deli, seating inside
or take out
Hours: 10:00-7:00pm Monday-Friday, 11:00-3:00 Saturday, Closed Sunday

(6) I-Ho's Korean Grill
1216 W. Lincoln St.
(406) 522-0949
Location: 7 min. walk southwest of the SUB just off Lincoln St. behind MSU Alumni building
Style of food: Korean with table service
Hours: 11:00am-9:00pm

(7) Junga Juice
815 W. College
(406) 586-9137
Location: 5 min. walk north of the SUB just west of the intersection 8th and College St.
Style of food: Fruit Smoothies only with counter service
Hours:10:00am-7:00pm Monday-Saturday, Sunday 10:00am- 6:00pm

(8) Lemongrass Thai
290 W. Kagy
(406) 551-2168
Location: 10 minute walk south of campus, on corner of Wilson and Kagy.
Style of food: Table service.
Hours: 10:00am-3:00pm, 5:00pm-9:00pm

(9) MoBerry
280 W. Kagy
(406) 586-6279
Location: 10 min. walk south of campus, on corner of Wilson and Kagy.
Style of food: Premium frozen yogurt
Hours: 11:00am-9:00pm

(10) Pickle Barrel
809 W. College St
(406) 587-2411
Location: 5 min. walk north of the SUB just off the intersection 8th and College St.
Style of food: Deli sandwiches with counter service and ice cream
Hours: 10:00am-10:00pm

(11) Rosa's Pizza
123 W Kagy Blvd
(406)-586-8808
Location: 10 min. walk south of campus, on corner of Wilson and Kagy
Style of food: pizza, delivery or seating inside
Hours: 11am - midnight

(12) Sola Café
290 W Kagy
(406) 551-2168
Location: 10 min. walk south of campus, on corner of Wilson and Kagy
Style of food: Espresso, pastry, salads, soups, panini, microbrews & wine. Takeout or seating inside
Hours: 6:00am-9:00pm

(13) Spectator's Bar and Grill
19 Tai Lane
(406) 587-2156
Location: 7 min. walk southwest of the SUB just off the intersection of Lincoln St. and Tai Lane.
Style of food: Burgers, sandwiches, pizza, and appetizers with table service
Hours: 7:30am – midnight

(18) Granny's Gourmet Donuts
3 Tai Lane.
406-922-0022
Location: 7 min. walk southwest of the SUB just off the intersection of Lincoln St. and Tai Lane.
Hours of operation: 7:00am-2:00pm Tuesday-Friday Saturday 8:00am-2:00pm

(19) Seven Sushi Sake
270 West Kagy Blvd.
(406) 586-7874
Location: 10 min. walk south of campus, on corner of Wilson and Kagy
Style of food: Table Service
Hours: 11:30am-10:00pm, except Sunday 4:30pm-10:00pm

(20) Town & Country Foods
1611 South 11th Avenue
(406) 587-5541
Location: 5 min. walk west of campus, across from the Brick Breeden Fieldhouse on 11th.
Style of Food: Deli style with soup and salad bar. Seating Available.

Coffee

14 SRO
In the SUB
Location: Just down the hall from the Ask Us Desk in the SUB
Hours: 7:00am-4:00pm

15 The Daily
1013 W. College St
406-585-8612
Location: 8 min. walk north of SUB off the intersection of 11th and College St.
Hours: 6:30am-7pm weekdays, 7am-5pm weekends

16 International Coffee Traders
720 S. 10th Ave
406-585-8612
Location: 6 min. walk north of SUB behind the Conoco gas station
Hours: Open Mon-Thu 6:30am-10pm; Fri 6:30am-7pm; Sat 7am-7pm; Sun 7:30am-9pm

17 The Brewed Awaking
In the Renne Library
406-858-8612
Location: In the Library's main lounge
Hours: Mon-Thurs 7:30 am to 11:00 pm, Friday 7:30 am to 4:30 pm, Saturday 11:00 am to 4:30 pm, Sunday 1:30 pm to 11:00 pm