

**Human - Machine Cooperation in Archaeology,
Epigraphy and Ancient History**

Wednesday

9:00 **Gathering**

9:30 **Opening and Greetings**

Session: Technology

Chair: Aren Maeir, Bar Ilan University

10:00-10:25 Eugene Ch'ng, Digital Heritage Centre, University of Nottingham Ningbo China: Reconstructing Accessible Pasts via Virtual Reality

10:25-10:50 Roy Abitbol, IBM and University of Haifa:
Automatic Assembly of Ancient Papyrus Fragments

10:50-11:15 Ethan Fetaya, Bar Ilan University & Shai Gordin, Ariel University:
Machine assisted restoration of fragmentary Akkadian texts

15 mins break

Session: Ancient Near East

Chair: Shai Gordin, Ariel University

11:30-11:55 Enrique Jiménez, LMU:
The Electronic Babylonian Literature Project: Towards the Automatic Reconstruction of Babylonian Literature

11:55-12:15 Maarja Seire, Leiden University:
Networks of Scribes: The social and legal conventions of scribal practice in Babylonia

12:15-12:40 **Lunch break**

14:00-14:45 Adam Anderson, U.C. Berkley: Workshop: Social Network Analysis

15 mins break

Session: Archaeology

Chair: Joe Uziel, Israel Antiquities Authority

15:00-15:25 Ladislav Šmejda, CULS Prague:
The power of cloud-computing for an archaeological analysis of remote sensing data

15:25-15:50 Chris McKinny, Texas A&M University Corpus Christi; Jane Gaastra, University of Exeter & Itzick Shai, Ariel University:
Recording Destroyed Buildings with Construction Software – Results from the Last Eight Seasons of Using PlanGrid at Tel Burna

15:50-16:15 Svetlana Matskevich, University of Haifa:
Public Policy (or lack thereof) in Digital Archaeology and Digital Humanities

15 mins break

Session: Jewish Studies

Chair: Eshbal Ratzon, Ariel University

16:30-16:55 Orit Rosengarten, Israel Antiquities Authority:
Researching the Dead Sea Scrolls through imaging technologies

15:55-17:20 Bronson Brown deVost, University of G ttingen
Scripta Qumranica Electronica and the (Hu)man behind the Curtain

17:20-17:45 Menachem Katz, Hemdat Hadarom College and The Friedberg Jewish Manuscript Society & Hillel Gershuni,
Hebrew University of Jerusalem: Contribution of Digitization to Identifying Tiny Manuscript Fragments in the Dead Sea Scrolls and in the Cairo Genizah Fragments

17:45-18:10 Hayim Lapin, University of Maryland & David Loshin:
Citation and Text Reuse in the Rabbinic Corpus

Thursday

Session: Technology

Chair: **Itzick Shai, Ariel University**

10:00-10:25 Lee-ad Gottlieb, Ariel University; Eshbal Ratzon, Ariel University; Dimid Duchovny; Jakub Zbrzezny, Ariel University: Machine learning techniques for Aramaic

10:25-10:50 Niv Derech, The Technion; Ayellet Tal, The Technion & Ilan Shimshoni, University of Haifa and The Technion: Solving Archaeological Puzzles

10:50-11:15 Amos Azaria and Shai Gordin, Ariel University:
Human Computer collaboration for studying life and environment in Babylonian exile

15 mins break

11:30-12:30 Asaf Gayer, University of Haifa:
Workshop: Digital Reconstruction of Dead Sea Scrolls Fragments

Lunch in Jerusalem

Tour of The Israel Museum & Israel Antiquities Authority Laboratory

Moving Beyond Interfaces: Reconstructing Accessible Pasts via Virtual Reality

Eugene Ch'ng

Director, NVIDIA Joint-Lab on Mixed Reality, NVIDIA Technology Centre

Co-editor-in-chief, PRESENCE: Virtual and Augmented Reality

University of Nottingham Ningbo China

Virtual Reality is rarely understood as space that has the potential to become places rather than mere interfaces with headsets and controllers. Much of the developmental history of VR has focused on hardware and software interfaces that give access to virtual environments, and on the rendering of believable computer graphics. In the midst of such developments, the formation of the virtual and digital heritage community since the 1990s have applied the use of accessible technologies for exploring reconstructed built heritage, and moving from virtual reality facilitated tours, to the realisation of the need to incorporate virtual life, and living agents into such environments. In parallel, the three decades of research into the effects of immersion into VR and human factors involved in achieving a state of presence have progressed well to-date, these have established schools of thoughts, principles, and associated presence concepts which have become useful in the construction of virtual environments. The recent technology corporations' investments in developing VR and AR for consumers have resolved some persistent issues, and this, together with 3D capture technologies such as photogrammetry have brought virtual heritage into another stage. Whereas past virtual heritage environments allow us to 'see' a representation of the past, present virtual heritage environments can give access to the experience of the past. Where built heritage was the previous focus, highly detailed and interactable virtual heritage objects have now become possible. Virtual heritage research is now at another stage of development, and there is the need now to explore not only experiential virtual sites, but to understand virtual spaces as potential heritage 'place' where not only interpretations can occur, but also that

the formation of users' personal meanings and memories towards a heritage site can become the focus. The talk presents recent research into the phenomenology of virtual heritage sites, and why the understanding of the experience of users beyond interfaces are important. The talk expounds research results from several case studies as a means to solidify the concepts presented above – the crowdsourcing simulation of mass photogrammetry of over 300 objects, monuments and sites in Asia, China, and Europe, the scanning of a ~2,000 years old Tiantong Temple, the 19th century Southern Chinese clan temple, the Shiqiaotou village, the reproduction and reconstruction of the Yuan Dynasty Maritime Silk Road Port and how these models are used in immersive technologies such as VR and AR to create value for research and education.

The talk explores the notion of our present ability to reconstruct a version of reality from a material past that still has a physical existence, including the work needed to accumulate fragmented heritage and fill up gaps in historical information in order to visualise and communicate heritage and historical information accurately. The talk articulates both the thought process above, and the methodological approaches in digitally reproducing cultural heritage using accessible imaging devices and drones. Furthermore, questions on the challenges of storage, crowdsourcing, ownership, authenticity and how models can be protected using technologies are investigated.

Automatic Assembly of Fragments of Ancient Papyrus

Roy Abitbol

University of Haifa & IBM

The task of assembling fragments in a puzzle-like manner into a whole picture plays a significant role in the field of archaeology as it supports researchers in their attempt to reconstruct historic artefacts to gain evidence about historic events. In this paper we propose an algorithm for matching and assembling ancient papyrus fragments containing unknown scriptures. The batch of fragments we investigated was excavated from the Dead sea caves and is dated roughly circa the 1st century BCE. This batch is considered extremely challenging due to its poor condition and the fact that numerous researchers have tried to seek matches within it, using various methods.

Papyrus paper is created from papyrus plants and it has a typical threads pattern resulting from the plant's stems. The proposed algorithm is founded on the hypothesis that this threads pattern has unique local attributes such that nearby fragments have similar patterns. We posit that these similar patterns can be exploited using image processing and machine learning techniques to identify matching fragments. The algorithm and system which we present support the quick and automated classification of pairs of papyrus fragments in an attempt to identify pairs that have high likelihood of being a match.

The algorithm consists of a series of steps and is based on several machine-learning methods. The basic approach is to first deconstruct the problem of matching fragments into a smaller problem of matching edge areas (squares) between fragments. This first phase is solved using a convolutional neural network ingesting raw images of the edge areas and producing local matching scores. Later, we utilize these scores in order to conclude about the matching of entire fragments pairs by establishing an elaborate voting system. We enhance this voting by employing a set of alignment techniques and extracting spatial information.

Eventually, we feed the entire collected data into a Random Forest classifier in order to produce a higher order classifier capable of predicting whether a pair of fragments is matching or not.

Our algorithm shows excellent result on the validation set, which is of similar background as the training set, however, when run against the "real" test set of fragments for which we have no prior knowledge, the algorithm returns with a large set of positively classified pairs, of which the vast majority are clearly false. Experts reviewing the results have identified and ranked a small number of the positive matches as potentially true and referred them for further investigation. We conclude that the basic hypothesis is valid under suitable conditions. In order to succeed in any future attempt to classify this or any other set, using this algorithm, the prerequisite would be that the training set has to possess similar attributes and come from a similar background as the test set.

Machine-assisted Restoration of Fragmentary Akkadian texts

Ethan Fetaya

Bar Ilan University

Shai Gordin

Ariel University

The main source of information regarding ancient Mesopotamian history and culture are clay cuneiform tablets. Despite being an invaluable resource, many tablets are fragmented leading to missing information. Currently these missing parts are manually completed by experts. We will present our current work, exploring the possibility of automatically completing the holes in ancient Akkadian texts from Achaemenid period Babylonia by modelling the language using modern machine learning techniques.

The “Electronic Babylonian Literature” Project: Towards the Automatic Reconstruction of Babylonian Literature

Prof. Enrique Jimenez

Ludwig Maximilian University of Munich

The literature from Ancient Mesopotamia (approximately modern southern Iraq) is in a state of permanent reconstruction: the masterpieces of Babylonian literature, such as the Epic of Gilgamesh and the Flood Story, are riddled with lacunas, and a vast mass of fragments lies, unidentified, in the drawers and cabinets of museums. The job of modern Assyriologists is often compared to that of Renaissance scholars, who patiently put together texts that nobody had read in hundreds of years, and recovered them to the modern world.

The Electronic Babylonian Literature (eBL) Project brings together ancient Near Eastern specialists and data scientists to revolutionize the way in which the literature of Iraq in the first millennium BCE is reconstructed and analyzed. Generations of scholars have striven to explore the written culture of this period, in which literature in cuneiform script flourished to an unprecedented degree, but their efforts have been hampered by two factors: the literature’s fragmentary state of reconstruction and the lack of an electronic corpus of texts on which to perform computer-aided analyses. The eBL project aims to overcome both challenges. First, a comprehensive electronic corpus will be compiled, and legacy raw material now largely inaccessible will be transcribed into a database of fragments (“Fragmentarium”). Secondly, sequence alignment algorithms will be developed to query these corpora. These algorithms will propel the reconstruction of Babylonian literature forward by identifying hundreds of new pieces of text, not only in the course of the project but also in the decades to come.

In the course of the present talk, the project’s PI (Jiménez) will present the challenges that they aim to overcome, and the tools that they have developed or are currently developing.

Networks of Scribes: The social and legal conventions of scribal practice in Babylonia

Maarja Seire
Leiden University

Several studies discuss the document types and their legal formulas in Babylonia during the mid-first millennium BCE. However, little is known about the individuals who wrote these private archival documents. Assyriologists have often assumed that the individuals who wrote archival documents were professional scribes, and further speculated that they drew up documents against a fee. However, many 'scribes' wrote documents for themselves, or for their friends and family. Were there limitations to the autonomy that kinship groups in Babylonia seem to have enjoyed? Since private archival documents relate to family life, ownership and lease of property, employment and financial transactions, the networks of 'scribes' and their 'clients' could help in answering this question. My research is looking at the social and legal conventions that determined who could draw up binding agreements. In other words: Who could write which documents? The source material from the Neo-Babylonian and Persian period reaches up to 10,000 clay tablets, but I will use case studies to analyze the corpus. However, even then it is difficult to get a grasp on the connections between various individuals and the tablet trail that connects them. To solve this problem, my research relies heavily on social network analysis. Therefore, I will study scribal practice through network perspective.

Socio-Economic Networks from the The Ur III Sumerian Archives

Adam Anderson
University of California, Berkeley

Based on a three-year Data Science Discovery project at UC Berkeley, led by myself and Niek Veldhuis, we have build reproducible socio-economic networks from the Ur III textual archives (ca. 80,000 texts online). The results of this work have been checked and validated in a series of interactive workshops at UC Berkeley, which included the leading Ur III specialists from around the world: Manuel Molina (BDTNS-CSIC, Madrid), Marcel Sigrist, Steven Garfinkel, Paula Pauletti, and Stephanie Rost, to name just a few. Using Social Network Analysis (SNA), the project demonstrates methods for prosopographical disambiguation and deduplication, in order to visualize the highly interconnected commercial transactions chronologically and spatially with GIS, and to contextualize the intricate hierarchies of the individuals by their roles, positions, families, and institutions. I will present a subset of this project, focusing on the commercial network of Puzriš-Dagan, modern Drehem, in order to show how SNA can be used to advance our understanding of individuals within a complex administrative system through interactive models.

Cloud-based computing technologies for geospatial analysis of cultural landscapes

Ladislav Šmejda
CULS Prague

This presentation discusses emerging tools for semi-automatic processing of large collections of remote sensing and spatial data. Satellite sensors, aerial imagery and numerous GIS datasets contain a treasure trove of information about spatial organization of landscapes inhabited by human populations adapted to diverse environments. Some data reveal fragments of the past directly as they have been collected by historians and archaeologists. However, even the present-day monitoring of the Earth's surface by advanced imaging and mapping systems provides invaluable insights into trajectories of cultural landscapes development. The patterns of contemporary land use have usually resulted from previous long-term evolutionary trajectories of human-environment interactions. In this sense we can speak of entire landscapes as specific categories of cultural heritage, where their spatial segmentation, distribution of soil types and vegetation patterns have their own historic memory and can be studied as archives, accumulated over different periods of time. Modern technological infrastructures and their application programming interfaces (APIs) allow for time and cost-effective handling and analyses of extensive datasets. Without such human-machine cooperation, making use of broadband Internet services and powerful computing infrastructures, our opportunities to study landscapes across various space-time scales would be very limited.

Recording Destroyed Buildings with Construction Software – Results from the Last Eight Seasons of Using PlanGrid at Tel Burna

Chris McKinny
Texas A&M University, Corpus Christi
Jane Gaastra
University of Exeter
Itzick Shai
Ariel University

Since 2012, the Tel Burna archaeological project has used the construction app PlanGrid as its platform for archaeological recording. In this timeframe, PlanGrid has proven to be a reliable, powerful, and innovative digital tool for use in field excavations. Over the last several years, the project has also used Agisoft Metashape (formerly Photoscan) to create a daily 3D photogrammetric model and 2D daily top plan, which is then integrated into PlanGrid. This paper will discuss the integration of these two systems while also comparing the advantages and disadvantages of using PlanGrid/Metashape over some other digital recording systems. This paper will also serve as a seminar for demonstrating how to implement and use PlanGrid together with Agisoft Metashape in excavations.

Public Policy (or lack of thereof) in Digital Archaeology and Digital Humanities

Sveta Matskevich
University of Haifa

The main purpose of this paper is to evaluate the current state of affairs in the policy making in Digital Archaeology and Digital Humanities – two relatively young disciplines that could make a good use of the support from the governmental institutions. I will argue that the landscape of this policy is a complex entity that partly overlaps cultural and educational policies but also has its unique features. Several examples of such policy making activities around the world, mainly in Europe, will illustrate the thesis. This will be followed by some suggestions, what could be done in our region, within Israeli legal, political and religious realm.

Researching the Dead Sea Scrolls through imaging technologies

Orit Rosengarten
Israel Antiquities Authority

In 2011 the Israel Antiquities Authority (IAA) began imaging both sides of every fragment of the Dead Sea Scrolls (DSS) in 28 exposures and 12 wavelengths with a designated system developed and built by MegaVision Ltd. The digitization project initially started as a conservation effort to monitor the physical state of the DSS, and soon become an unreplaceable tool for DSS research. The images produced by the imaging system are the basis of an online, free access digital library and of many international collaborations and joint advanced projects using high end technology to better our understanding on different aspects of the DSS. Following the success of the multispectral images the IAA has sought out to look for new technologies that can answer unsolved issues, such as micro-CT scans on a few selected artifacts that enable us to virtually unroll scrolls or open separate swabs, revealing their content which would otherwise remain a mystery. In the following lecture, I will present an overview of the multispectral imaging project, its outcomes and other technologies in use today by the DSS unit of the IAA.

Scripta Qumranica Electronica and the (Hu)man behind the Curtain

Bronson Brown-deVost
University of G ttingen

The Scripta Qumranica Electronica project is working to provide a web based platform for the development and publication of digital critical editions of fragmentary Dead Sea Scrolls. As a large international project with humanists and computer scientists (or digital humanists as the case may be) as well as institutional elements, we have learned many lessons about the horizons of current technologies, the difficulties of navigating the interactions between man and machine and bringing a common platform to a diverse audience, and the ever present challenges of data format, data rights, attribution, and the costs of development and deployment. I will share a selection of examples dealing with these topics within the scope of the Scripta Qumranica Electronica project, largely focussing on the role human elements play in defining the cooperation between man and machine.

Contribution of Digitization to Identifying Tiny Manuscript Fragments in the Cairo Genizah Fragments and in the Dead Sea Scrolls

Menachem Katz
Hemdat Hadarom College & The Freidberg Jewish Manuscript Society
Hillel Gershuni
Hebrew University of Jerusalem

The Taylor-Schechter collection in Cambridge University Library contains hundreds of thousands of manuscripts and manuscripts' fragments. Some of them contains dozens of leaves, but most of them are torn leaves. Identifying and joining the fragments is a task that many researchers have been doing for more than hundred years, and the process is still far from finish. In this presentation I would focus on the tiny fragments that don't have a full shelfmark for themselves, rather they listed together with many others like them in shelfmarks that contains usually dozens of minute fragments. Lately there have been a progress towards identifying them, with the aid of the Friedberg's Genizah Project website and the tools that have been developed there to that end. I will show that even though the fragments are tiny, there is a hope to identify them because it's likely that a significant part (and perhaps almost all) of them came from other leaves in the same sub-collection of shelfmark. I will lay down some lines for enhancing the digital tools to help identifying them. Lastly, I will discuss the probable application for the tiny fragments of the Dead Sea Scrolls.

Modeling Corpus as Graph

Hayim Lapin

University of Maryland

David Loshin

College of Information Studies, University of Maryland

One of the principle characteristics of rabbinic literature is its referentiality: its reuse of expressions, terminology, and sometimes whole traditions explicitly as commentary or citation, but also silently through repurposing. We present on early stages of modeling the classic rabbinic corpus as a graph, focusing on passages with identical or similar text and limited to three works: Mishnah, Tosefta, and Sifra. This opens queries related to dependency, sources, and "genetic" development (did the editor of the Sifra have "the" Mishnah, or only common traditions--or vice versa?), as well as (at a preliminary level) of topic clustering (are the same topics discussed together in the Sifra, which is organized around a biblical book, and in the Mishnah and Tosefta, which are not?). We provide a brief demonstration of the model, with some sample queries and results, and conclude by outlining a more extensive next model.

Machine learning techniques for Aramaic

Lee-ad Gottlieb

Ariel University

Eshbal Ratzon

Ariel University

Jakob Zbrzezny

Ariel University

Dimid Duchovny

We study the computational aspects of several major dialects of Old and Middle Aramaic. The first Aramaic inscriptions date to the 10th century BCE, in Syria. By the middle of the first millennium BCE, Aramaic had become the lingua franca of the Achaemenid Empire, and spread to the Middle East and Central Asia. Aramaic was widely used in both religious and common contexts throughout antiquity, and evolved over time into numerous dialects, including Ancient, Imperial, Biblical, Judean, Babylonian, Jewish Palestinian and Syriac. We present techniques and methods to study linguistic problems for several of these dialects. Problems of interest include dialect determination and similarity, document dating and author attribution. We present techniques and methods to study linguistic problems for several of these dialects. Problems of interest include dialect determination and similarity, document dating and author attribution.

Solving Archaeological Puzzles

Niv Derech
The Technion
Ayellet Tal
The Technion
Ilan Shimshoni
University of Haifa & The Technion

This paper focuses on the re-assembly of an archaeological artifact, given images of its fragments. This problem can be considered as a special challenging case of puzzle solving. The restricted case of re-assembly of a natural image from square pieces has been investigated extensively and was shown to be a difficult problem in its own right. Likewise, the case of matching "clean" 2D polygons/splines based solely on their geometric properties has been studied. But what if these ideal conditions do not hold? This is the problem addressed in the paper. Three unique characteristics of archaeological fragments make puzzle solving extremely difficult: (1) The fragments are of general shape; (2) They are abraded, especially at the boundaries (where the strongest cues for matching should exist); and (3) The domain of valid transformations between the pieces is continuous. The key contribution of this paper is a fully-automatic and general algorithm that addresses puzzle solving in this intriguing domain. We show that our approach manages to correctly reassemble dozens of broken artifacts and frescoes.

Human-Computer collaboration for studying life and environment in Babylonian exile

Amos Azaria & Shai Gordin
Ariel University

In this talk we will describe an efficient NLP model for spanning the full semantic fields of words and sentences, written in the Neo-Assyrian dialect of Akkadian in thousands of cuneiform documents on clay, dating back to the Iron-Age period (c. 900 - 625 BCE). In our research we aim to adapt NLP models to the specific domain of partially readable texts written in ancient Semitic languages. Our approach makes use of the word embedding capabilities of the Google BERT (Bidirectional Encoder Representations from Transformers) for obtaining numeric vectors (word embeddings), accumulating the semantic and contextual properties of every word and then, given a query for a semantic field of a single word, uses one of the unsupervised clustering algorithms, such as K-Means, DBSCAN etc. to group the appearances of this word across the ancient documents by their common semantic properties, resulting with as complete as possible definition span of the word on its distinct tints.

Digital Reconstruction of Dead Sea Scrolls Fragments

Asaf Gayer

University of Haifa; Scripta Qumranica Electronica

A hands-on workshop for introducing simple and available graphic design tools for material reconstruction of the Dead Sea Scrolls – the oldest jigsaw puzzle in the world. Participants will have a taste of the digital possibilities of scroll reconstruction – restoration of fragments, digitally joining fragments and combining text and images on a digital canvas. Requirements: Laptop computer (with a full battery – recommended); Microsoft Word and PowerPoint (or equivalents); GIMP-image manipulation software, free download available here: <https://www.gimp.org/downloads/>