The Cucuteni-Tripolye Archaeological culture

Modelling Networks of Settlements

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What is the Cucuteni-Tripolye archaeological culture?

The Cucuteni-Tripolye (CT) culture comprises inter-connected societies in present-day Romania, Moldova and Ukraine from ca. 4800–3000 BC.

The emergence of the CT culture was characterised by a shift in lifestyle in the region, from hunter-gatherer to increasingly organised agriculture, craftsmanship and commerce.

What is the motivation for modelling the CT networks of settlements?

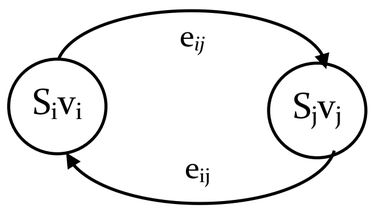
In addition, archaeological data suggests the existence of CT "megasites", which were amongst the largest cities in the world. The sophisticated planning and methods required to maintain such settlements suggest an advanced culture. This project is the preliminary investigation into work proposed by a group of researchers at Newcastle University School of Mathematics and Statistics. We wish to understand the social and trade interactions within the CT culture, in order to develop a deeper understanding of the culture.

What is the scope of this project?

The main focus of the project has been the confirmation of our model against work published by Knappett *et al.* on modelling networks of settlements in the Middle Bronze Age Aegean. A basic range of geographical factors are used in the implementation of the model. Following the confirmation of the model, we performed a preliminary analysis of archaeological data from the Cherkassy region in Ukraine.

Variables

- S_i - resources available to settlement i
- v_i - exploitation of resources of settlement i
- d_{ij} - distance between settlements i and j
- e_{ij} - importance of interaction with settlement j for settlement i
- D - constant used to scale distance
- $V(d_{ij}/D)$ - Interaction potential between settlements i and j



The interaction mechanism between settlements i and j, where S_iv_i is 'absolute size'.

Social Cost/Benefit function

$$H = -4\kappa R - \lambda E + jP + \mu T$$

- R - benefit of exploitation of resources
- E - benefit of interaction (or trade)
- P - cost of maintaining population
- T - cost of interaction (or trade)

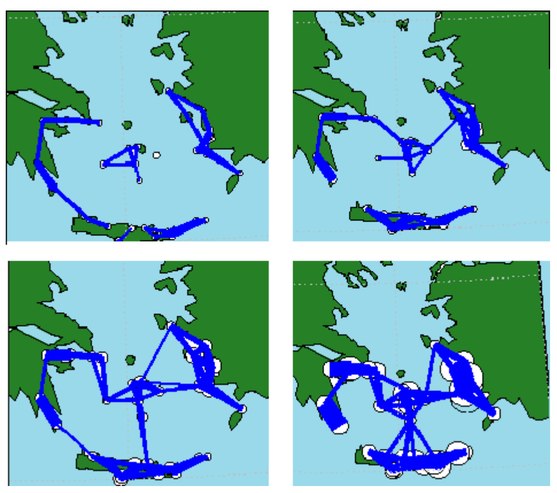
Optimisation method

- Simulated Annealing
- Repeatedly tests different configurations to find optimal configuration

The Middle Bronze Age Aegean

Our model is based on the methods used by Knappett *et al* to model networks of settlements. We focused on their paper modelling trade networks between Asia Minor, Cyclades, Greek mainland and Crete clusters in the Aegean.

The effect of varying trade coefficient, λ, on trade links between clusters is investigated. We effectively calibrate our model using the Knappett *et al* paper.



In these simulations, we fix:

- κ=1, j=0.5 and μ=0.1

We vary λ as follows:

- λ=1 (top left)
- λ=2 (top right)
- λ=3 (bottom left)
- λ=4 (bottom right)

Trade incentive increases proportionally to λ.

Results

- At low trade incentives, most trade takes place within clusters; the cost of trade with settlements in other clusters is too high.
- As trade incentive increases, trade links within clusters become stronger and trade between clusters increases
- Throughout the simulations, the central cluster (Cyclades) of islands acts as a gateway for trade due to its position.
- Whilst resources on islands may be limited, their 'gateway' role in the trade network allows settlements in the Cyclades cluster to flourish.
- Large sites form in Asia Minor and Crete, which suggests that the trade network may be weighted in favour of these clusters. Even though the model cannot give an explanation, it raises an interesting question to be investigated.

The CT culture - Cherkassy region

We are interested in this region for two main reasons:

- It is one of the most widely researched areas of Ukraine
- Megasites such as Talyanki settlement were discovered in this region in the CI (3600-3000BC) phase of the CT culture.

Model details

- Initial absolute sizes of all sites are kept equal, in order to avoid bias in growth of sites
- Geographical factors such as proximity to rivers and altitude are not included in model; The optimisation occurs on a flat, two-dimensional map
- The shortest distance between two points on a sphere is used to calculate distance between settlements
- The interaction potential function incorporates the difficulty of travelling and trading over increasing distances into the model

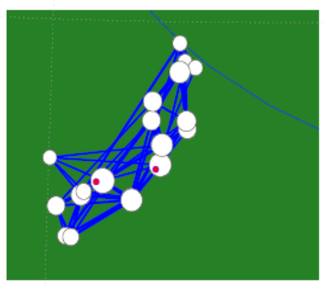
Limitations

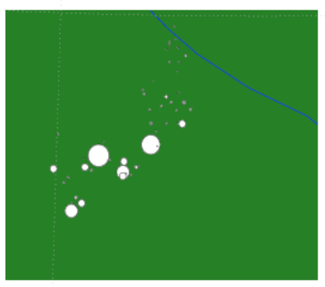
- Geographical factors need to be included in the model for a more robust analysis of the networks
- Distance should be based on optimal paths between settlements, which are calculated using information such as proximity to rivers and the topography of the region
- We aim to resolve these issues in future work

Results and Discussion

Our preliminary work in the CI phase of the Cherkassy CT culture do not show "megasite" formation. However, the largest sites in the simulation correspond to the megasites in the archaeological data. This implies that the model is suitable for analysing the trade and other social interactions between settlements in general.

However, refinements need to be made to the underlying assumptions and implementation of the model to obtain more accurate results.





Simulation in the CI phase of the Cherkassy CT culture:

- Simulated network (left)
- Archaeological sites (right)

We believe that network analysis provides a versatile approach to analysing population dynamics. Its primary strength lies in the ability to incorporate additional factors into an existing model. The use of stochastic methods in the implementation of these models also take uncertainty and variability of behaviour into account.

References

Knappett *et al, Modelling Maritime Interaction in the Middle Bronze Age Aegean,* Antiquity, **82**, 2008

Acknowledgements

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