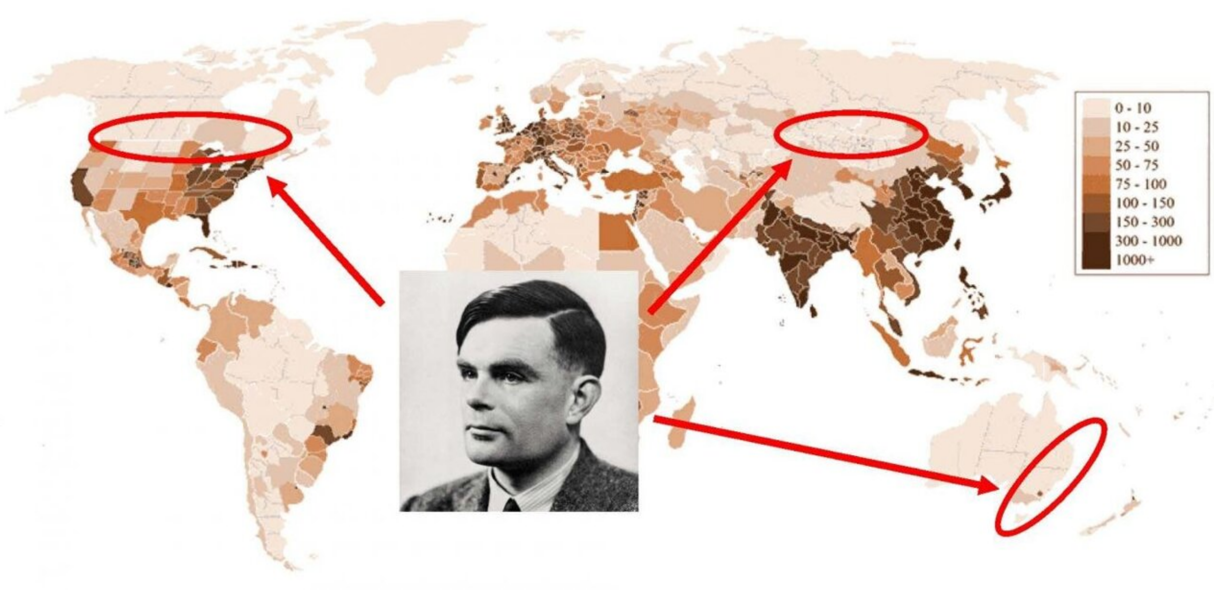
How can we stop mankind from stagnating?

April 28 2021



Alan Turing's theory of pattern formation may explain human population distribution across the world. Credit: University of Leicester

Fast growth of the global human population has long been regarded as a major challenge that faces mankind. Presently, this challenge is becoming even more serious than before, in particular because many natural resources are estimated to deplete before the end of this century.

The increasing population pressure on agriculture and ecosystems and the environment more generally is predicted to result in worldwide food and water shortages, pollution, lack of housing, poverty and social tension. The situation is exacerbated by global climate change as considerable areas of land are predicted to be flooded and hence taken out of human's use.

It is widely believed that, unless alternative scenarios of sustainable population growth and social development are identified and implemented, mankind is likely to experience stagnation or even decline.

Population growth in time is complemented with the population dynamics in space. Population distribution over space is hugely heterogeneous for a variety of reasons, to mention the climate, the history and the economy just as a few. The spatial heterogeneity may result in significant migration flows that in turn can have a significant feedback on the local demography and the population growth.

On a smaller scale of individual countries and states, understanding of the factors affecting the population distribution in space is needed to ensure adequate development of infrastructure, transport and energy network.

Poorly informed decisions are likely to result in overcrowding and social problems in urban areas and/or lower quality of life in rural neighborhoods. Identification of scenarios of sustainable population growth and social development on various spatial and temporal scales requires good understanding of the relevant processes and mechanisms that affect both the population growth and the population distribution. Arguably, such understanding is unlikely to be achieved without a well-developed theory and the corresponding mathematical/modeling framework.

Indeed, mathematical models of human population dynamics has a long history dating back to the seventeenth century. Over the last few decades, the need for an adequate and efficient mathematical theory of the human population dynamics has been reflected by a steady growth in the number of studies where problems of demography along with related issues of economy were considered using mathematical models, tools and techniques.

In our recent paper, we use mathematical modeling to address the phenomenon of heterogeneous spatial population distribution. Heterogeneity of geographical features (mountains, forests, rivers, etc.) and natural resources (e.g. coal, iron and copper ore) are commonly accepted as factors leading to the demographic and economic heterogeneity.

Here we ask a question: is this natural heterogeneity the only underlying cause, or can there be another and perhaps more general principle responsible for emergence of heterogeneous population distribution? In order to answer this question, we first revisit available data on the population density over a few areas in different parts of the world to show that, in all cases considered, the population distribution exhibits a clear nearly periodic spatial pattern in spite of the fact that the environmental conditions are relatively uniform. Being inspired by this finding, we then consider a novel model of coupled economic-demographic dynamics in space and time and endeavor to use it to simulate the spatial population distribution. The model consists of two coupled partial-differential equations of reaction- diffusion type.

Following a similar modeling approaches that was successfully used in ecology and biology we then show that the emergence of spatial patterns in our model appears to be possible as a result of Turing instability.

Although it is not our goal to provide any direct comparison between the real-world demographic patterns and the model properties, we regard the qualitative agreement between the model predictions and the data on the human population density as an indication that the heterogeneous population distribution observed across different countries in different continents may, at least in some cases, have been caused by endogenous rather than exogenous factors, i.e. may have appeared due to intrinsic Turing instability of the corresponding economic-demographic dynamical system.

In many countries, the population distribution over space is distinctly heterogeneous, e.g. urbanized areas with a high population density alternate with rural areas with a low population density. Apparently, spatial variation in geographical and climatic factors can play a significant role in shaping the population distribution.

Our main hypothesis in our paper is the existence of a dynamical mechanism that may lead to the formation of heterogeneous population distribution regardless of the geographical heterogeneity. In our search for the real-world examples we focus on the cases where the environment may be regarded, up to a certain spatial scale, as relatively uniform. The environmental properties that we consider here as proxies for the environmental heterogeneity are the elevation, the annual mean temperature and the annual mean precipitation.

More information: Anna Zincenko et al, Turing instability in an economic–demographic dynamical system may lead to pattern formation on a geographical scale, *Journal of The Royal Society Interface* (2021). DOI: 10.1098/rsif.2021.0034

Provided by University of Leicester

Citation: How can we stop mankind from stagnating? (2021, April 28) retrieved 7 August 2024 from https://phys.org/news/2021-04-mankind-stagnating.html

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.