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December 1, 2020

Center for Latin American Studies
Stanford University
Tinker Seed Grant Proposals

Dear Alberto and Elizabeth,

I am pleased to submit a proposal for Tinker Seed Grant funding on behalf of my team of graduate students and postdoctoral scholars. Our project is titled: **Urban growth, informal housing and the production of inequality in Latin America.**

The proposed CLAS seed project aims to extend existing strands of work in a novel direction by collecting and tagging 100s of thousands of Google Street View images sampled from the peripheries of dozens of Latin American cities. The collection and tagging of these images is not exceptionally expensive, but it does require seed funding to build up the database to an adequate scale. Collecting so many images requires a solution to the problem of storage and access. Tagging requires the use of crowdsourcing, in this case with targeted paid participants located in Latin America. We seek to draw on the local knowledge of everyday people in the region in order to better classify images of housing, rather than use generic and culturally unspecific AI/computer vision methods. With these elements in place, we will be in a position to use our existing methodology on a large sample of cities in order to assess the diverse ways that urban growth generates housing inequality. In summary, the two challenges that have slowed our progress in this research have been storage and image tagging by knowledgeable humans. A seed grant from CLAS-Tinker would provide the resources we need to make substantial progress and complete the research relating to at least four scientific papers now in planning stages. It would also serve as an impetus to forge even stronger connections between History graduate students and CLAS (connections that have, in the past, led to good outcomes by way of conferences and other events), as we would propose to hold team meetings and other events at Bolívar House when the health conditions allow.

Sincerely, [redacted]

[redacted]

Urban growth, informal housing and the production of inequality in Latin America

[redacted]

*Collaborators expected to participate in the expanded project if funded

General Project Statement:

This project seeks to utilize computer vision and AI methods in order to assess landscape change in cities in the developing world. The focus of the work is on cities in Latin America, where PI Frank and his team have the greatest domain expertise. Additional comparative work, with Dr. Jo, includes a study including South Korea, based on her local expertise, as a point of comparison with cities in Brazil. The fundamental question asked in this research is whether and how Google Street View imagery can be classified and analyzed in order to provide high resolution information regarding landscapes on the margins of cities. The work to date has shown that computer vision/AI methods can classify landscapes in a robust and reproducible manner, allowing for quantitative assessment of environmental conditions in peripheral zones of cities. What is needed, at this stage, is better resources for storage and better and larger numbers of tagged images for training AI models.

Methods and Data:

Recent studies of rapid urban growth normally use a combination of remote sensing (RS) and GIS data [1-3]. Our analysis adds a third variable in the form of Google Street View (GSV) imagery. The advantage of using data from RS and GSV is that both sources are as close as we can come to direct, unfiltered observation of the built environment shorn of preconceived categories such as census definitions or political boundaries. This section provides an overview of our sources and methods.

The growth of urban areas was measured using the GHSBUILT raster from the Global Human Settlement Layer project [4-5]. This multi-temporal layer is a processed raster derived from Landsat satellite images and indicates the presence of human built-up structures with high resolution (30m.) Each pixel of the grid represents a 30-by-30 meter area classified as "built" or "not built." Based on the methodology developed by the Atlas of Urban Expansion, we calculated the level of urbanization for each pixel, "defined as a circle with a one-square-kilometer area and a 584-meter radius, roughly a ten-minute walk" [5]. This procedure was repeated for the years covered in the dataset (1975, 1990, 2000, 2014), which allowed us to track changes over time in the urban extent of the city.

In order to complement and extend the analysis made possible through the use of remote sensing, we also employ street-level imagery sampled from Google's Street View platform, which we analyze using computer vision models. For this process, we used each city's residential street network to select approximately 20,000 points randomly in the urban extent defined by the satellite imagery described above. Our sampling method enforced a minimum distance of 25 meters between points in order to assure reasonable uniformity in coverage. We then downloaded one image for each point (chosen randomly from the existing images dating from 2010-2019). Due to limitations in the GSV coverage, some observations did not have a corresponding GSV image.

The images were then analyzed using computer vision, an application of artificial intelligence that handles visual information. Our computer vision models tagged each image according to three variables related to urban vulnerability: investment, residential density, and stability. Investment considered the level of public and private capital invested in the landscape, such as visible in the infrastructure and buildings. For example, landscapes with well-maintained streets and tendered gardens were labeled invested; graffiti, makeshift housing, and unpaved roads were considered signs of impoverishment and lack of investment. Residential density refers to the number of people that reside in that part of the city. It contrasts landscapes with large apartment complexes with dispersed single-family houses. Lastly, stability considers visual markers that indicate potential changes in the landscape, such as active constructions or improvised housing. Our approach to building and implementing this computer vision model with respect to GSV imagery builds upon the small but growing literature on this subject, which has generally attempted to assess urban change, such as gentrification, with reference to Street View data [4-6].

Expected Research Output:

We developed the methodology with the support of a grant from Stanford Human-Centered AI Institute (HAI) and this grant will allow the creation of a database of approximately one million GSV images for fifty cities in Latin Americas. They will base three case studies that we will submit for publication in 2021.

The first case study will compare the effects of zoning in producing urban vulnerability in major cities in Brazil (Belo Horizonte, Curitiba) and Mexico (Guadalajara, Hermosillo). Based in our pilot study on Guadalajara, where we detected the concentration of impoverished GSV images in formerly ejidal land, we seek to understand more broadly what kinds of institutional arrangements were more conducive to poverty, marginalization and displacement. Similarly, the second study will evaluate the impact of political boundaries in producing visually distinct urban landscapes, based on comparison of cities in the US-Mexico border (such as in El Paso-Juarez and Laredo-Nuevo Laredo.) The last case study will focus on Colombiam mid sized cities, which had a more “regular” pattern of growth than extremely large metropoles such as São Paulo and Mexico City, assessing the relationship between urban sprawl and population growth.

The three case studies will follow a similar structure as our existing pilot study, which is currently under review by the journal *Land*. Collectively, these papers will add up to an overview of the process of urbanization in Latin America and, in the next stage of the project, to comparison with other world regions.

The fourth paper now in planning stages seeks to explore the question of privacy bias in GSV images by contrasting the degree of “exposure” of private spaces in wealthier versus poorer neighborhoods in Belo Horizonte, Brazil and Seoul, South Korea. This research serves to connect our study of Latin American cities to other world regions. It also serves as a critique of the naive use of GSV images. Google takes these photographs without the permission of the residents in the structures we examine. Wealthy people can hide behind high walls. We aim to problematize this aspect of this emerging field of study and apply these insights reflexively across all of our research output.

Finally, we expect to continue to apply for external grants in order to fund this suite of research projects in the years to come. We have, for example, partnered with a team of scholars at North Carolina State University on an NSF grant proposal that is currently under review. It is our hope that this project can foster collaboration and research productivity for Stanford students interested in urban change in Latin America for years into the future.

References:

[1] Mohapatra, S. N., Pani, P., and Sharma, M. "Rapid Urban Expansion and its Implications on Geomorphology: A Remote Sensing and GIS Based Study." Geography Journal (2014)

[2] Corbane, Christina; Florczyk, Aneta; Pesaresi, Martino; Politis, Panagiotis; and Syrris, Vasileios. (2018): GHS built-up grid, derived from Landsat, multitemporal (1975-1990-2000-2014), R2018A. European Commission, Joint Research Centre (JRC).44225.

[3] Angel, Shlomo; Blei, Alejandro M.; Parent, Jason; Lamsom-Hall, Patrick; and Galarza Sánchez, Nicolás. “Understanding and Measuring Urban Expansion.”Atlas of Urban Expansion-The 2016 Edition, Volume 1: Areas and Densities.

[4] Ji, W.; Ma, J.; Twibell, R. W.; and Underhill, K. "Characterizing Urban Sprawl Using Multi-Stage Remote Sensing Images and Landscape Metrics." Computers, Environment and Urban Systems30 (2006): 861-879.44928.

[5] Kang, et al. "Building Instance Classification Using Street View Images." 2018.

[6] Hwang, J. and Sampson. "Divergent Pathways of Gentrification: Racial Inequality and the Social Order of Renewal in Chicago Neighborhoods." ASR: 2014.

Budget:

Description	**Needs/Explanation**	**Cost**
External SSD hard-disk (>=8TB)	We currently host our images in old external drives (which are very slow) and on cloud services (which generate monthly costs based on the size of storage and usage.) A large-capacity SSD hard-disk speeds up the process and eliminates monthly payments.	$2,000
Image Tagging (Amazon MTurk)	The project will train three different models specific to Latin American cities to identify visual signs of impoverishment, residential density, and built environment's stability (or likelihood to change.) Based on our current procedures, we estimate being able to produce a state-or-art CV model with training datasets of approximately 3,000 tagged GSV images for each of the categories. To produce these datasets, we will use Amazon's Mechanical Turk, a service widely used by the AI community to build training sets for AI systems that connect developers with collaborators worldwide, following pay rates compatible with California's minimum wage. We estimate that a single GSV tagged image will cost approximately $0.70, considering that it is central for the research design to select images from our comprehensive dataset at random and include for training only those that five different taggers agree about its visual characteristics. A particular advantage of this method is the ability to tap on local sources of knowledge that otherwise would be extremely costly. While many projects using AI are liable to criticism for being culturally blind by imposing local visual standards to broader geographic areas, hiring people in Latin America to tag urban landscapes of their own countries will add nuance to our models.	$6,300
Research Assistants	We want to hire one undergraduate research assistant to supervise image tagging, at $17/hour, 5h/week for the next two quarters.	$1,700
Cartographic and Design Consulting	The project relies heavily on maps and visualizations, which will be included in the papers submitted for publication and other research outputs (like presentations). The item of the budget will allow us to produce high-quality visualization.	$2,000
Graduate Students	Some graduate students are involved in the project, and we plan to compensate with small stipends ($1,500/quarter.) Leonardo Barleta is in charge of the project's technical development and will work on the project for the next two quarters. Jonatan Perez and Christian Robles-Blaez will contribute with their research expertise, respectively, in US-Mexico borderlands and Colombia to draft the articles we plan to submit in each of the next two quarters.	$6,000
Total		*$18,000*