A cost-effective laser scanning method for mapping stream channel geometry and roughness

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Abstract

In this pilot project, we combined an Arduino Uno and SICK LMS111 outdoor laser ranging camera to acquire area scans of the channel and bed for a temporarily diverted stream. The 5m by 2m area was scanned at a 4mm point spacing which resulted in a point cloud density of 5600 points/m^2. A local maxima search algorithm was applied and a grain size distribution of the stream bed was extracted. The system resolved both large-scale geometry (e.g. bed slope and channel width) and small-scale roughness elements (e.g. grain sizes between about 30mm and 255mm) in an exposed stream channel thereby providing a resolution adequate for estimation of ecohydraulic roughness parameters such as Manning's *n*.

Hardware Setup

Laser scanner components

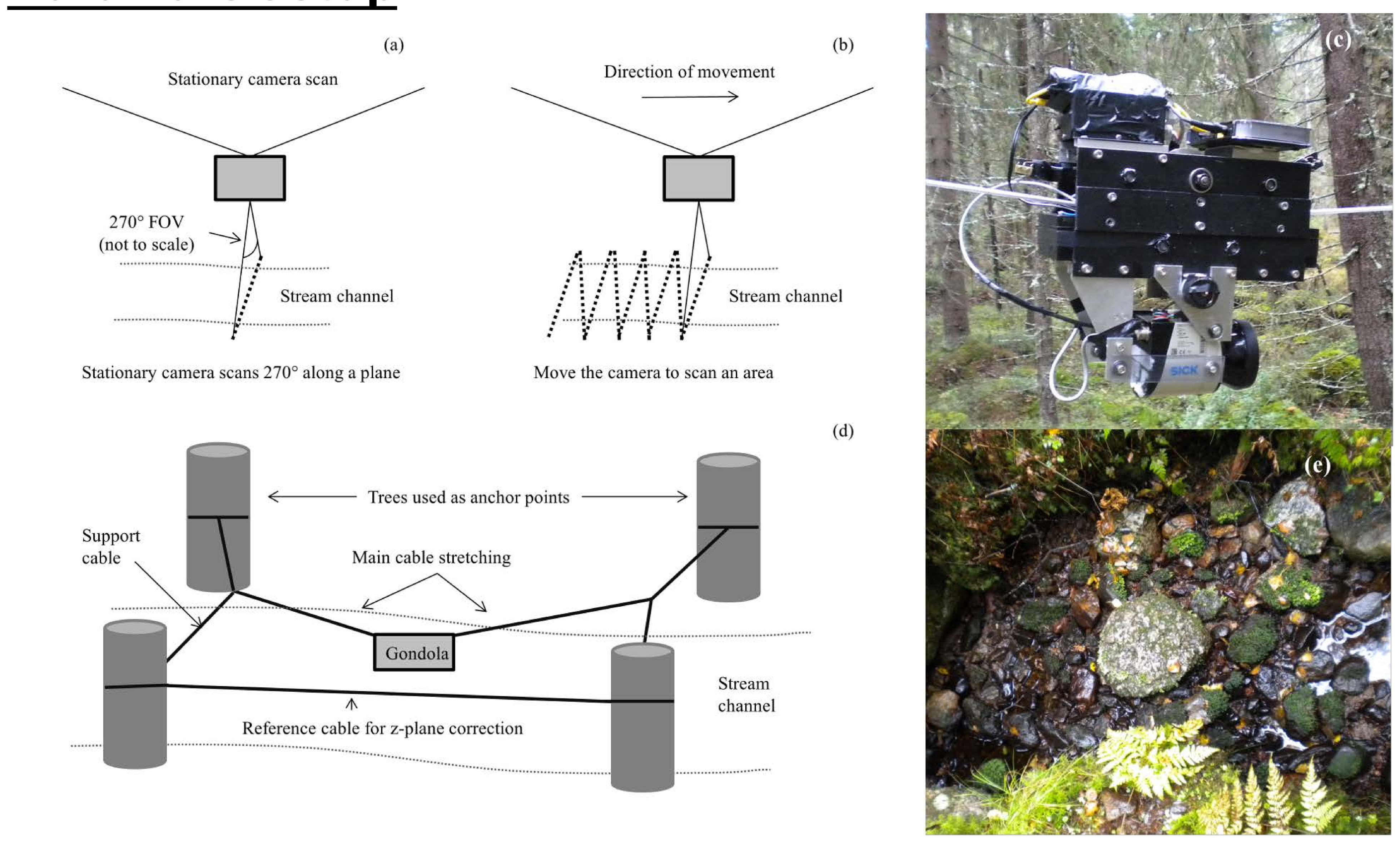
- SICK LMS111 outdoor laser ranger mounted in custom gondola
- Arduino Uno controlled servo motors and sending of xyz data via wifi network

Camera/data specifications

- 905nm laser (near-infrared, absorbed by water)
- Systematic error: ±30mm
- Maximum scan distance: up to 20m
- Point spacing of 4mm was achieved
- Stream was temporarily diverted

Total cost:

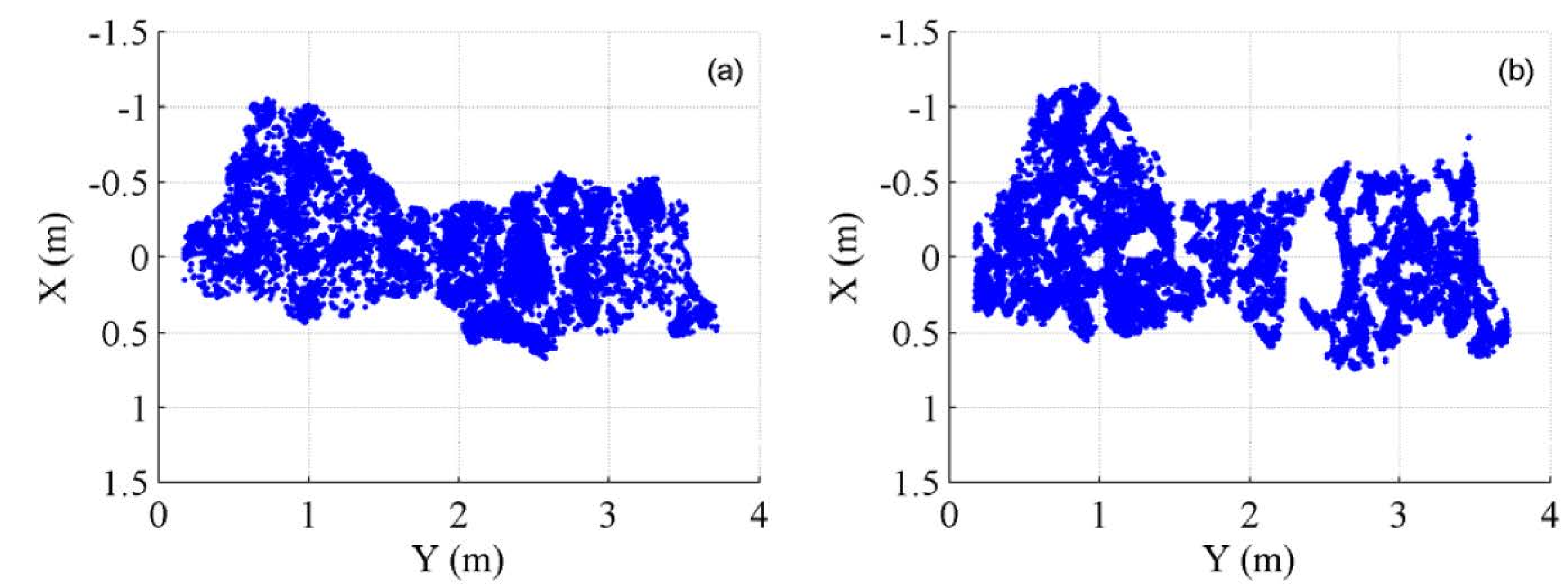
- 4500€



Processing Steps

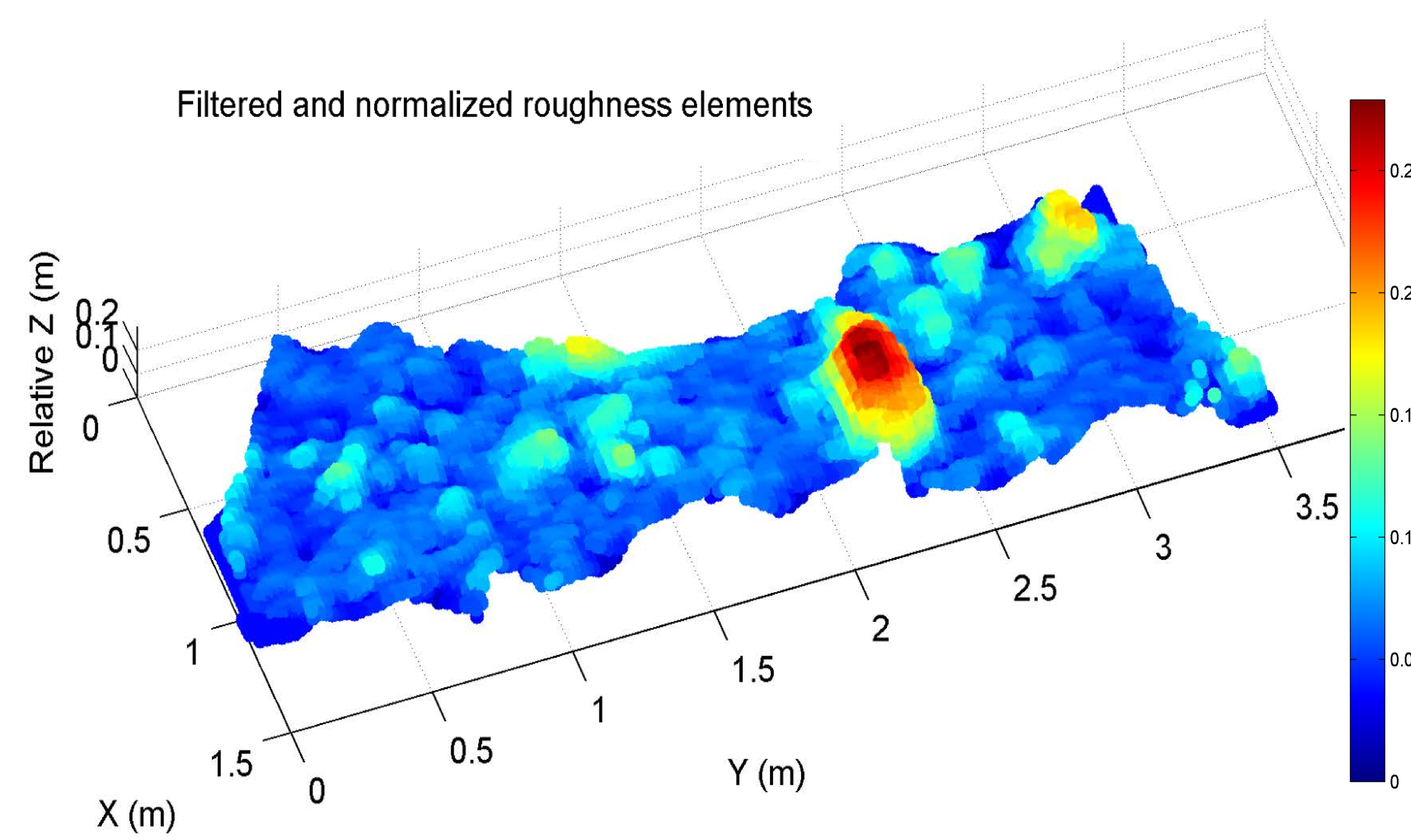
Extracting roughness elements

- Normalized for channel slope and classified into 2 classes:
  - Roughness elements (a)
  - Channel bed (b)



Roughness estimation

- Normalized surface at 4mm spacing was used to identify individual roughness elements
- Applied local maximum search with 7x7 cell window (±30mm) to identify protruding axis



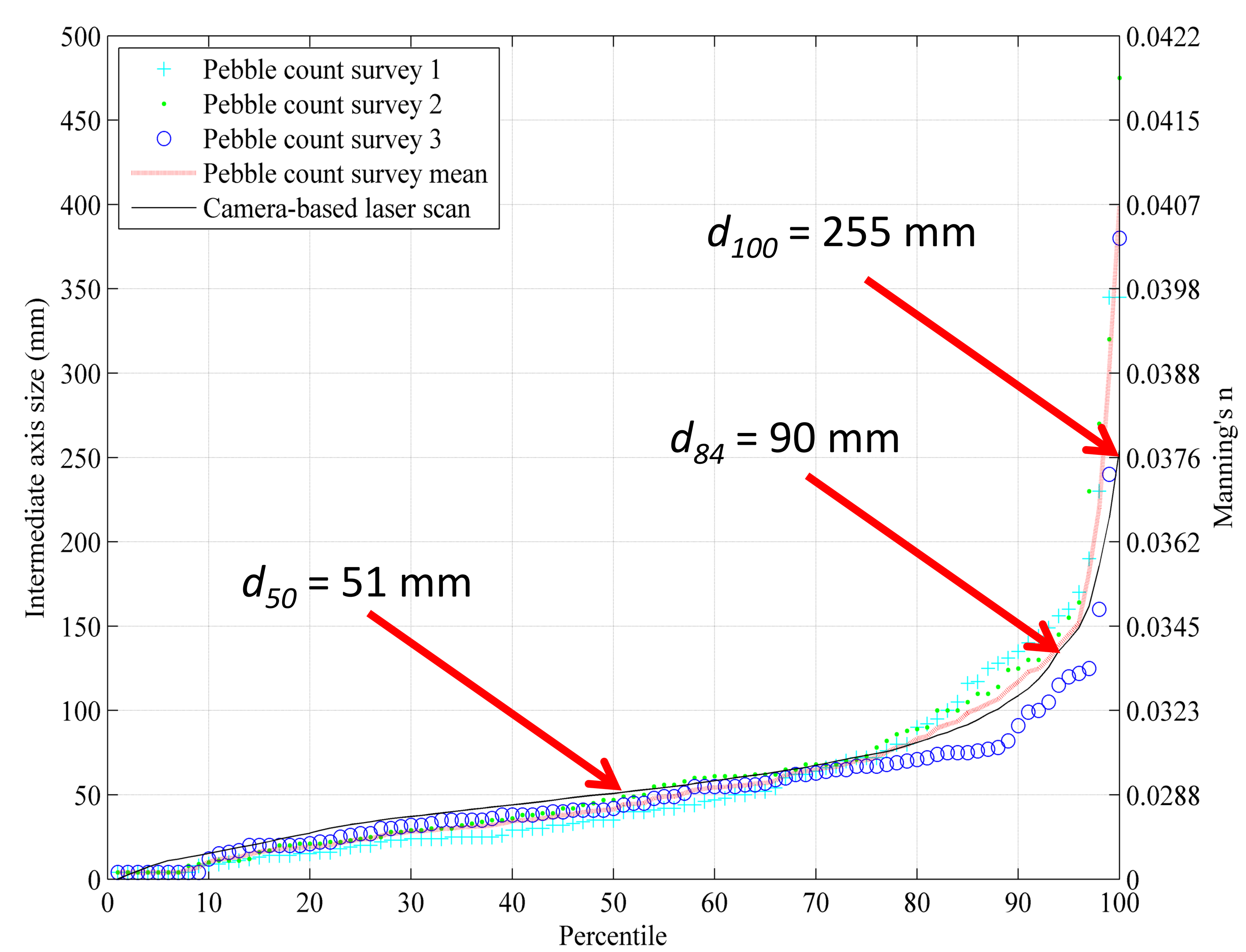
Results

Results – small scale

- d_{50} (median) modeled elements were equivalent to measured values
- d_{100} (largest) modeled element about 35% smaller than mean of largest recorded pebble size
- d_{84} (commonly used) modeled element about 7% larger than mean d_{84}
- Small modeled elements about 10mm but in practice should be se at 30mm (systematic error)

Conclusion

- Camera-based laser scanning system presented here offers a viable, cost-effective alternative able to resolve both large-scale channel geometry and small-scale roughness elements. The initial case study considered here shows such a system's promise for practical application in particular for those working on a limited or fixed research budget.



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