Robotic Cotton Harvesting—Is It Like Picking Apples?

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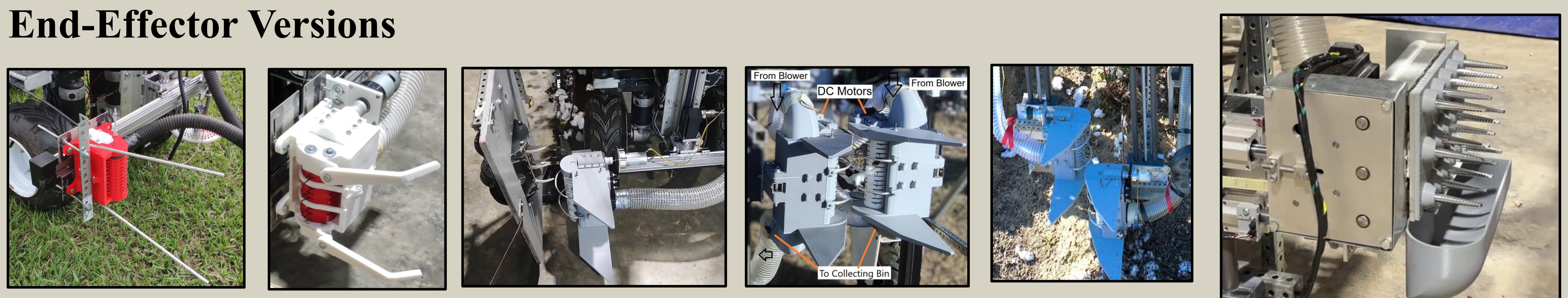
Introduction

- ❑ Most robotic harvesting systems (e.g., apple, strawberry, oranges, tomato, mushroom) rely on vision-guided selective picking, localizing individual and harvesting one object at a time.
- ❑ Existing robotic cotton harvesting studies largely follow the same single-boll detection and picking paradigm, suffering slow operational speed and limiting its field-scale practicality.
- ❑ Unlike high-value crops such as apples, selective single-boll robotic cotton harvesting is time and resource inefficient due to the low individual economic value and high density of cotton bolls.
- ❑ We propose a vision-guided cotton cluster harvesting approach, enabling simultaneous harvesting of multiple bolls, improving efficiency and sustainability.

Materials and Methods

I. End-Effector Versions



V1 V2 V3 V4 V5 V6 (latest)

Fig. 1: Previously studied end-effector versions (V1–V5) based on a roller-tine cotton boll stripping mechanism, which struggled to harvest cotton from the inner canopy. The latest version (V6) uses a barbed spindle array, enabling effective cotton picking from both the inner and outer regions of the canopy.

II. Cotton Picker Spindle Array (CPSA) End-Effector Design and Doffing Mechanism

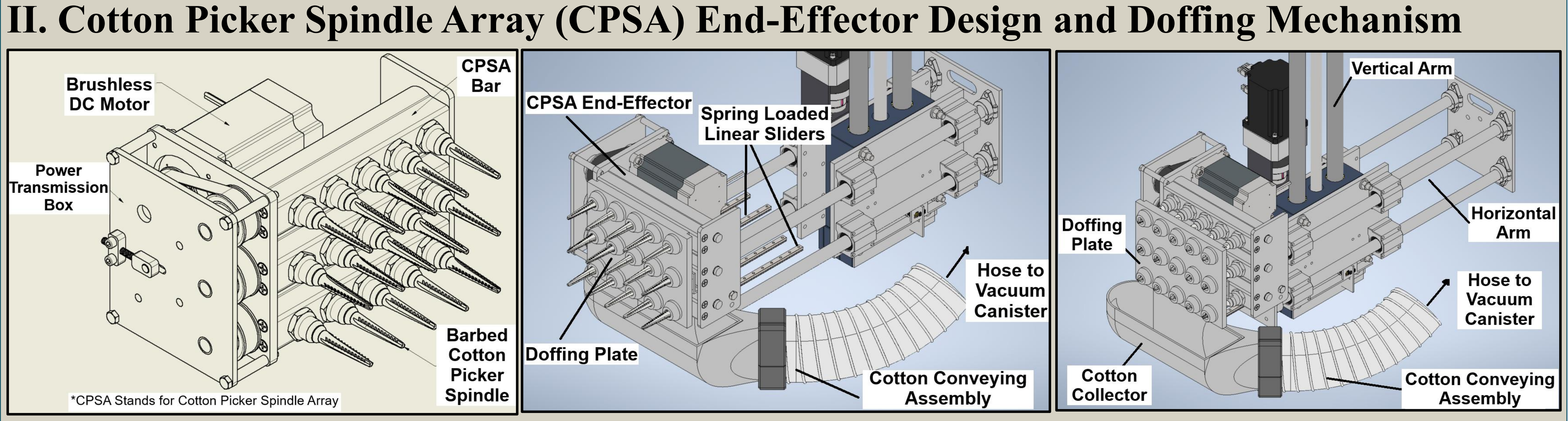


Fig. 2: CPSA End-Effector CAD design (left), and the doffing mechanism and sub-parts (mid and right).

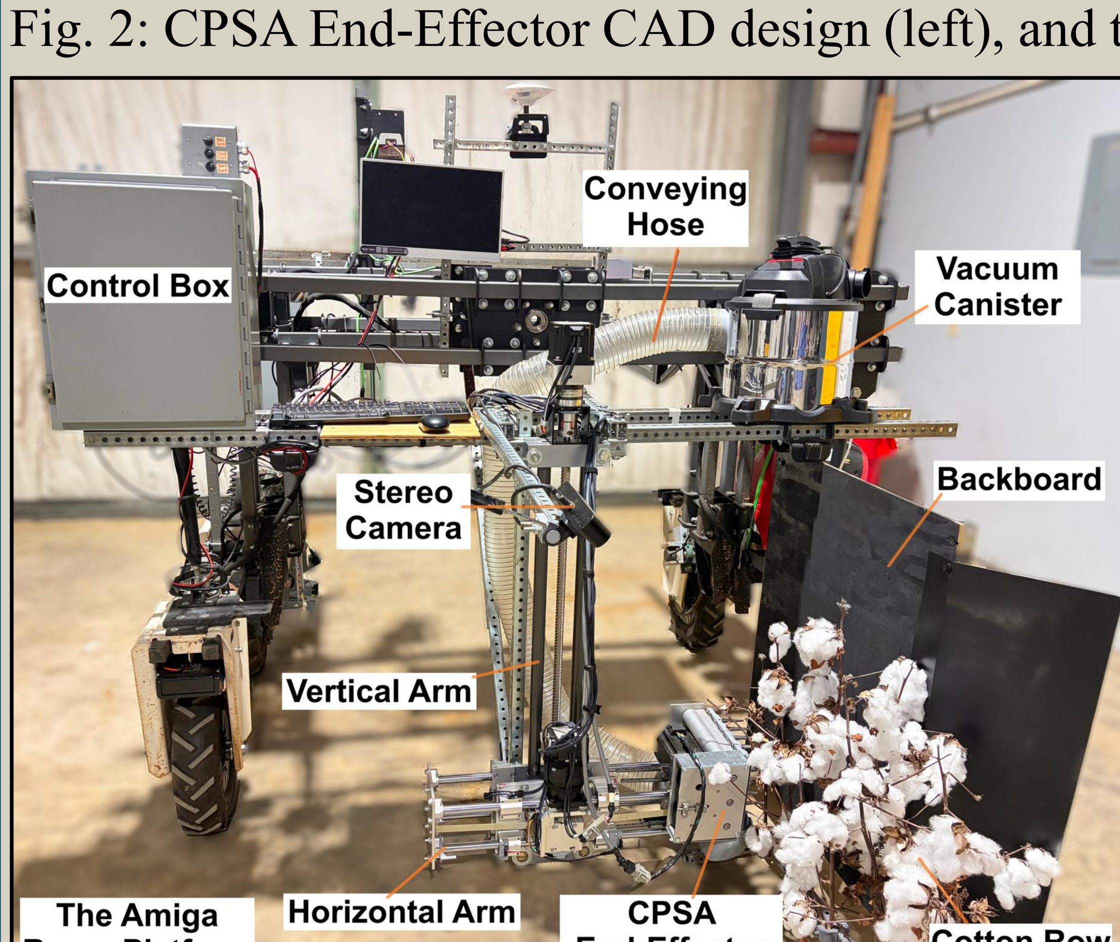
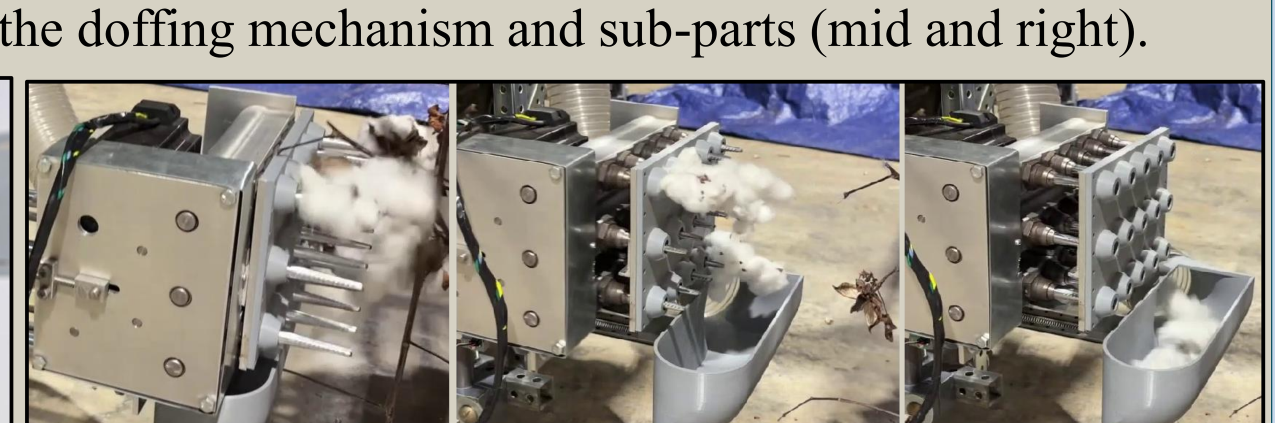


Fig. 3: Robotic cotton harvesting system attached on the base platform "The Amiga" rover.



A B C

A. The end-effector approaches the target cotton cluster, and the spindles begin rotating.
B. The end-effector retracts, and spindle rotation stops midway through retraction.
C. Upon full retraction, the doffing plate removes the picked cotton from the spindles and drops it into the collector.

Objectives

The primary goal of this study is to design a cotton picker spindle array (CPSA) end-effector capable of harvesting a cluster of cotton bolls simultaneously and to evaluate its picking efficiency. The specific objectives are to:

1. Design and fabricate the CPSA end-effector
2. Determine the optimal picking approach and the spindle speed for efficient picking and evaluate the overall efficiency of the end-effector

Results

I. Picking Approach/ End-Effector Trajectory

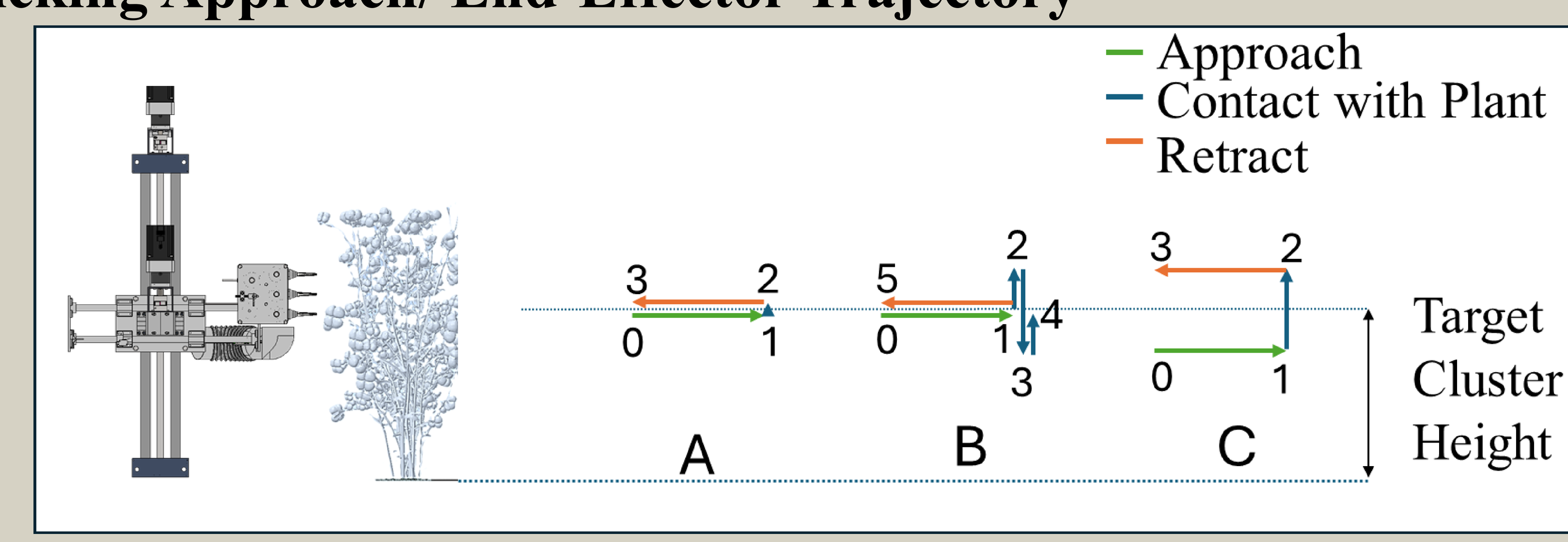


Fig. 4: Three end-effector trajectories (A, B, and C) for picking a target cluster of cotton bolls. Based on observations, trajectory C performed best among the three.

II. Spindle RPM and Performances

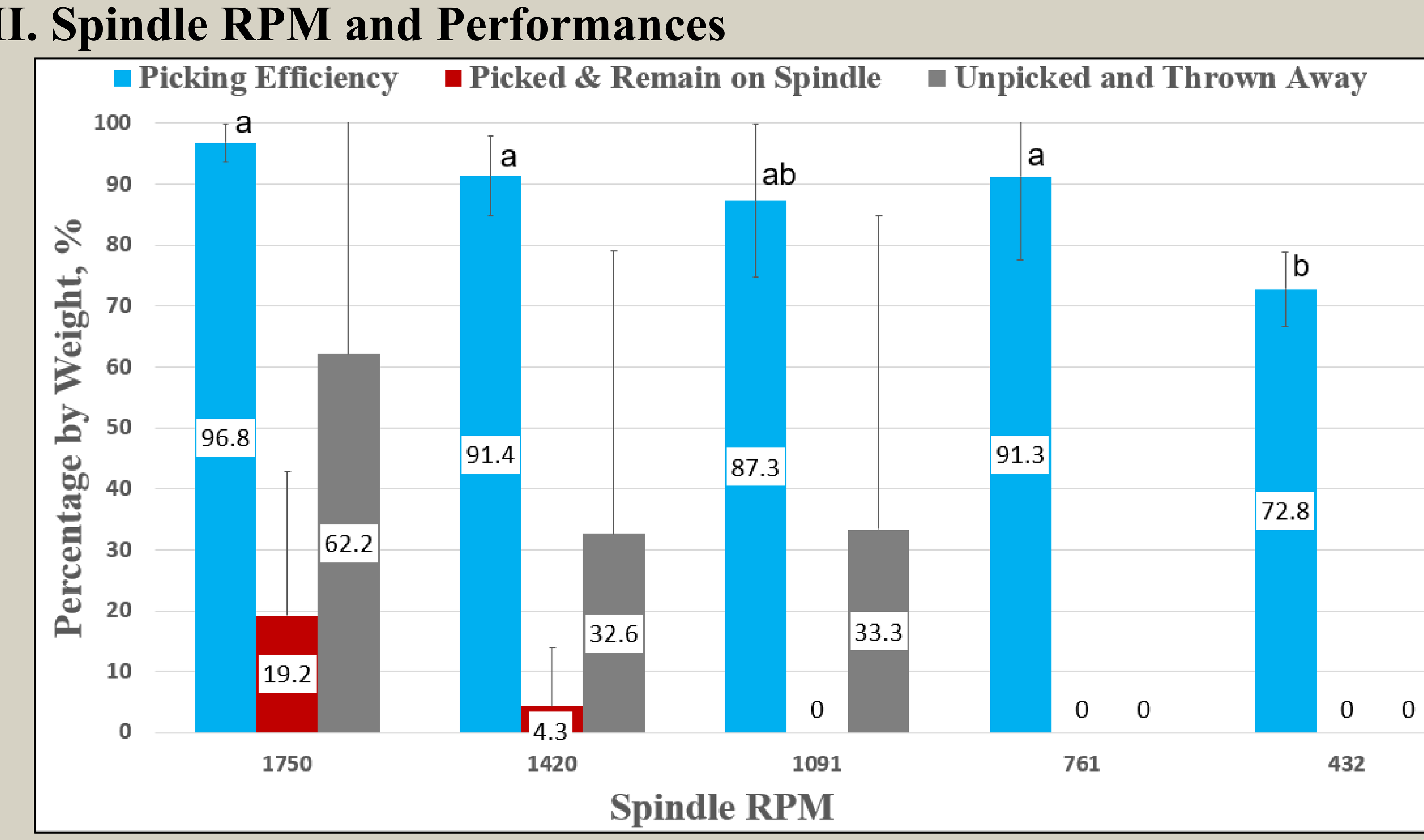


Fig. 5: (Left) picking efficiency, percentage of picked cotton retained on the spindles, and percentage of cotton thrown away due to centrifugal force at different spindle RPMs using trajectory C(1 pass) for target clusters located 300 mm above the ground. Optimal performance (above 91% picking efficiency per approach) was achieved at 761 RPM, with zero cotton loss and no cotton retained on the spindles. (Right) pictures of picked cotton at various RPMs.

Conclusions and Future Research

- ❑ A cotton picker spindle-array end-effector was designed and fabricated to harvest multiple bolls simultaneously, achieving optimal performance with the C trajectory at 761 RPM.
- ❑ Implementing a continuous picking and doffing mechanism would significantly improve harvesting speed.
- ❑ Development of an improved cotton conveying system and new baling mechanism

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