

Use of Universal Robots Collaborative Robotics (Cobots) in aid of demilitarization of Small Arms Ammunition (SAA)

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Figure 1: UR5e Cobot mounted in a workcell configuration prior to approach of the extraction cycle.

Introduction:

Conventional demilitarisation methods for small arms ammunition (SAA), such as open burning and detonation, are widely used due to their simplicity and effectiveness in hazard neutralisation. However, these processes significantly degrade recoverable materials and introduce environmental and regulatory concerns [1], [2].

Manual disassembly methods offer improved material recovery but are labour-intensive, inconsistent, and expose operators to explosive compounds, toxic residues, and mechanical hazards. These limitations reduce scalability and increase operational risk.

Recent advances in collaborative robotics (COBOTs) present an opportunity to introduce safer, semi-autonomous systems capable of operating alongside human operators. COBOTs offer advantages in precision, repeatability, and safety compliance, making them suitable candidates for hazardous material handling tasks.

This project investigated the feasibility of using collaborative robotic systems to perform mechanical disassembly of SAA, with a specific focus on projectile extraction from 7.62×39 mm cartridges.

Method & Results:

A dual-stage methodology was adopted, combining simulation and experimental validation to assess system feasibility.

Simulation Phase: Initial simulation work was conducted using NVIDIA Isaac Sim; however, due to instability within a virtual machine environment and the complexity of the platform, a transition was made to RoboDK. RoboDK provided a more practical and efficient environment for modelling robotic motion and enabled offline programming compatible with Universal Robots platforms.

- The simulation phase was used to:
- Develop a robotic workcell model
 - Define tool centre points (TCPs)
 - Validate reachability and motion paths
 - Ensure collision-free operation

However, it was identified that RoboDK does not simulate frictional contact or extraction forces, limiting its ability to predict real-world performance.

Experimental Phase: Physical trials were conducted using a UR5e collaborative robot in conjunction with a vice-based cartridge holding system.

- Multiple end-effectors were evaluated:
- OnRobot RG2 (parallel jaw gripper)
 - Robotiq Hand-E (adaptive gripper)
 - Collet chuck (custom gripping solution)

Performance was assessed based on:

- Grip success rate
- Extraction success rate
- Slippage behaviour
- Surface damage to components

Collaborative robotic systems were selected based on their compliance with safety standards and suitability for human-robot interaction [3].

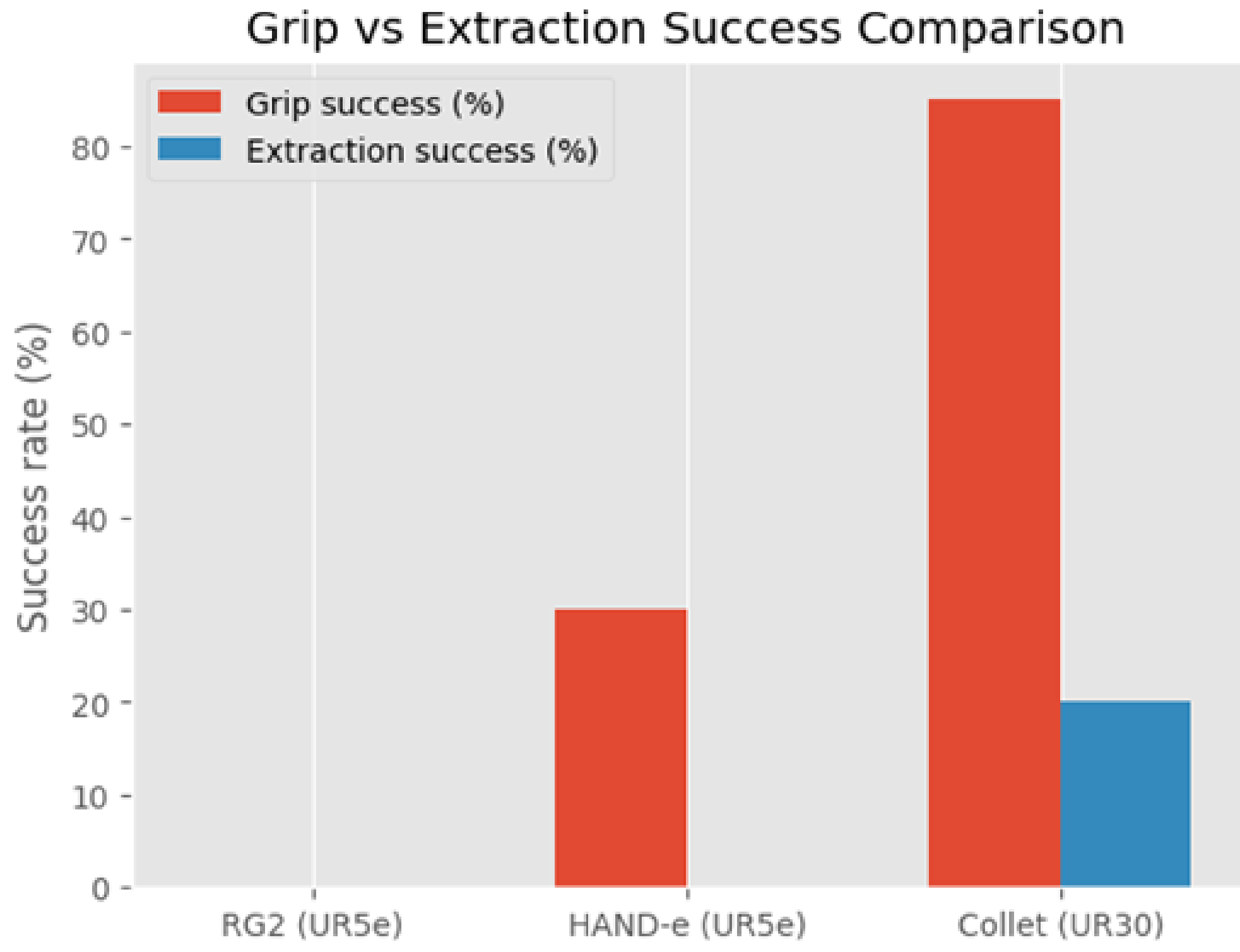


Figure 2: Percentage success rates of projectile gripping and extraction performance, evaluated over 20 trials for three different experimental configurations.

Key Observations

- Parallel grippers consistently failed to maintain sufficient frictional engagement, resulting in slippage during extraction attempts
- The Robotiq Hand-E gripper demonstrated improved grip in some cases but caused visible surface damage to projectiles
- The collet chuck significantly improved grip reliability through uniform radial compression
- Despite improved grip performance, extraction success remained limited

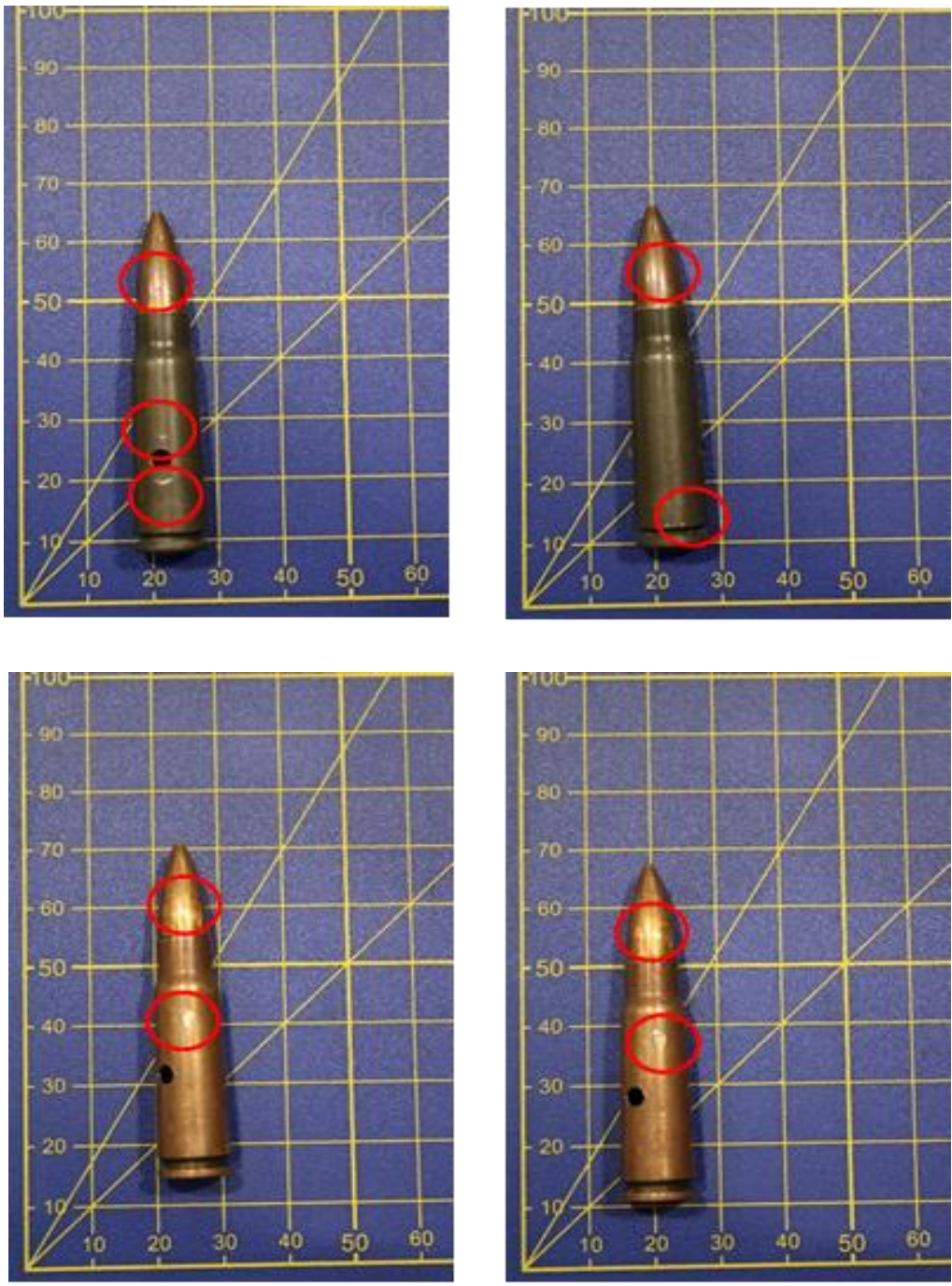


Figure 3: evidence showing surface damage to 7.62×39 mm cartridges, including scratching of the case and pronounced indentation on the projectile.

Discussion:

The results highlight a clear distinction between gripping capability and the force required to overcome projectile retention. While improvements in end-effector design (e.g. collet chuck) can significantly enhance grip stability, they do not address the fundamental limitation of collaborative robot force capacity.

Experimental observations indicated that the robot frequently reached joint or safety-related thresholds during extraction attempts, resulting in incomplete pulls. This suggests that the mechanical retention forces within the cartridge (driven by neck tension and friction) exceed the effective pulling capability of the collaborative robot.

These findings demonstrate that while COBOTs are well suited to handling, positioning, and low-force manipulation tasks, they are not inherently capable of performing high-force disassembly operations without additional mechanical assistance [4].

Additionally, surface damage observed on projectiles indicates that increased gripping force introduces trade-offs between grip reliability and component integrity [5] [6].

Future Work

- Development of purpose-built, optimised gripping systems
- Integration of auxiliary extraction mechanisms (e.g. servo-driven pullers)
- Evaluation of higher-force industrial robotic platforms
- Investigation of automated primer neutralisation systems
- Expansion of testing across multiple ammunition calibres
- Development of fully autonomous disassembly workflows

References:

[1] United Nations, "IATG 10.10: Demilitarization of Ammunition," 2015.
[2] United Nations, "IATG 10.20: Open Burning and Open Detonation," 2015.
[3] ISO, "ISO/TS 15066: Collaborative Robot Safety," 2016.
[4] International Federation of Robotics, "World Robotics Report," 2024.
[5] J. Akhavan, "The Chemistry of Explosives", 3rd ed., 2011.
[6] National Academies of Sciences, "Alternatives for the Demilitarization of Conventional Munitions," 2019.