A Bio-inspired Cat-Leap Parkour Rolling Mechanism (CPRM): Design Inception to Realization, and Applications

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***Abstract*—A bio-inspired novel CAT-leap parkour rolling mechanism (CPRM) is designed and developed for mobile robots. It was inspired by cat-leap jumping and monkey rolling motion. It enhanced the mobility of the mobile robot. Using CPRM, the robot can climb and cross unknown obstacles as well as perform locomotion. This mechanism protects the robot from unexpected impact forces on the robot during climbing and landing. It also can cross obstacles having double robot height. We developed a CPRM with a six-wheeled triangle-shaped mobile robot having two cat-leap arms for parkour rolling motion, allows a soft landing. We would like to share our experience working with CPRM mechanism and design from the inception to the realization, which includes design and iterations, prototype development, feasibility, functioning steps, advantages, and future applications.**

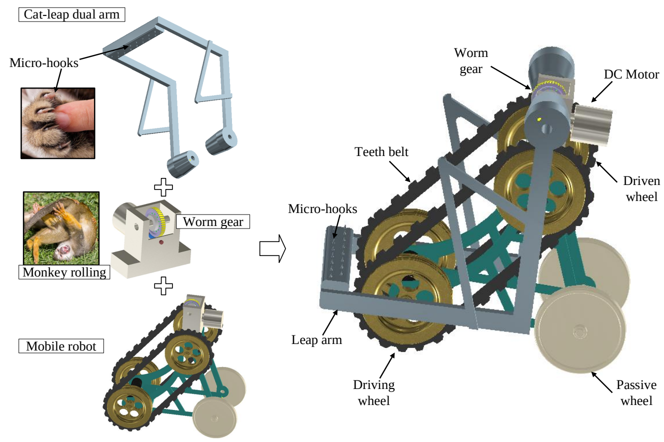

Fig. 1: Design inception: Motivation and CAD design of a cat-leap parkour rolling mechanism (CPRM)

I. INTRODUCTION

The super complicated mechanisms have passed through the design transfer process from inception to realization, and inception may come from realizing the designs in nature to design mechanisms closer to nature. Several bio-inspired mechanisms have been designed and developed to solve highly complex real-world problems in the past couple of decades. This approach has enormous potential to enhance conventional robots. Similarly, the work mentioned in [1] discusses a bio-inspired reconfigurable robot and its design and Implementation of a shape-shifting, rolling–crawling–a wall-climbing robot. A biologically inspired micro-vehicle capable of aerial and terrestrial mobile robots can do locomotion and also fly [2]. The conventional mobile robots only can provide locomotion on a flat surface [3]. However, they can not climb on random obstacles. That limits their usability in applications include surveillance, planetary exploration, patrolling, emergency rescue operations, etc. The traditional approach is directly jumping over the object, which may harm or destroy the robot structure due to massive impact reaction forces on its rigid body.

Therefore, we push their limits to enhance mobile robots' mobility by introducing a cat-leap parkour rolling mechanism, and it can perform a Parkour Rolling motion during locomotion like a monkey called the "Cat-leap parkour rolling mechanism (CPRM)." This mechanism allows a robot to climb on the obstacle, cross it, and keep locomotion. Its various design process from inception to realization, as shown in Fig. 1. The cat-leap stands mimicking the cat leap posture. It allows a strong attack and grips the obstacle like a cat. The cat always makes arm in leap shape before attacking the tall wall and hold the wall with pam's micro hooks for stable gripping, as shown in Fig. 1 (left-top). Both arms attach with a bar having several sharp micro hooks like a cat's nails. The sharp hooks can provide stable gripping on the unknown surface. A similar concept used by NASA developed a gravity-independent rock-climbing robot using compliant hooks gripper for sample acquisition and moving on obstacles [4]. The rolling word stands for a rolling feature and rolls his body along the arm during rolling like a monkey, as shown in Fig. 1 (left-middle), which allows soft landing. It also acts as a connecting medium of cat leap arm and mobile robot and provides rolling motion with self-locking to achieve a safe landing. The mobile was also modified, and it has a triangle-shaped frame with three wheels on each side. One has actuation, one is drive by a belt-drive, and one is a passive wheel, as shown in Fig. 1 (left-bottom). The triangle-shaped structure allows locomotion on all three sides of the triangle. The purpose of a belt is to pull up the robot on the obstacle, allowing crawling motion and moving over the obstacles. The belt absorbs massive impulsive forces and allows the robot's soft landing and movement on the obstacle surface. A conceptual CAD model of a cat-leap parkour rolling robot was designed in Autodesk Inventor design software and described in Fig. 1 (right). This mechanism has two unique features together, inspired by nature, a cat and a monkey.

Fig. 2 shows the realization of the CPRM mechanism by developing a prototype and investigating its functionality. Its has two specific operation mode. First is the locomotion mode, and the robot can move on the surface like a traditional robot,

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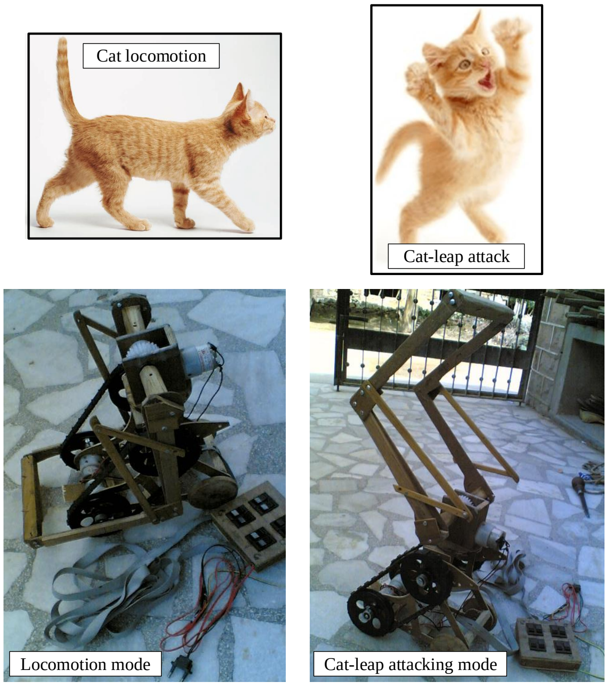

Fig. 2: Realization: Prototype and its operating mode

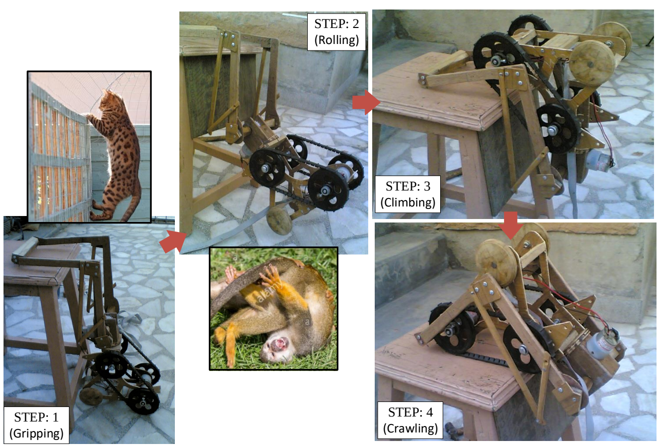

Fig. 3: Feasibility: Parkour rolling motion and its functionality

as shown in Fig. 2 (left). It can move forward, backward, left, and right like a cat. It is driven by a DC motor connected to a driving wheel on each side of a triangle-shaped mobile robot. The driving wheel can also move the robot on two sides of the triangular frame, allowing moving robots in different territories. Second is attacking mode like a cat attacking posture, as shown in Fig. 2 (right). In this mode, the robot allows us to attack the unknown obstacle and strongly grip it using micro-hooks.

We verified the mechanism's feasibility by performing a series of experiments and proposed its functionality in four steps; gripping, rolling, climbing, and crawling. We used stool as an obstacle on the smooth surface and functionality through various steps. The typical functional steps from initial to final are shown in Fig. 3. The one full cycle is called parkour rolling motion, and steps are described below:

STEP 1: This is an initial step and is called gripping. In this step, the robot's two leap arms move front and make attacking posture like a cat. The arm with micro hooks strongly grip the obstacle surface from the top (see Fig. 3, left).

STEP 2: The robot will make sure stable gripping than it starts to roll along the shoulder axis like a monkey, called rolling step, and rotate until the whole body touches the obstacle (see Fig. 3, middle).

STEP 3: After the rolling motion, the mobile robot starts to climb as the timing rubber belt rotates and pull-up until the robot's center of gravity comes up, and the robot becomes stable. The timing belt has several teethes to avoid slip between obstacle and robot. The purpose of the rubber belt is to absorb unexpected impulsive force while landing on the obstacle surface (see Fig. 3, right-top).

STEP 4: In this step, the robot starts crawling to pull the rest robot body and pull its center of gravity on the obstacle until it comes on the obstacle surface and stable (see Fig. 3, right-bottom). At last, the robot reconfigures in locomotion mode and continue the locomotion.

The combination of multiple bio-inspirations from nature could be more beneficial for the robot. We designed and developed a bio-inspired mechanism from design inception from nature to realizing by developing the parkour rolling robot, we found many advantages of a cat-leap parkour rolling mechanism, as listed below:

- This mechanism allows the robot to locomotion as well as climbing on the obstacle.
- The robot can climbs and cross over unknown obstacles.
- It also allows climbing the robot on an obstacle, having a smooth or rough surface with a strong gripping force.
- It can move over taller obstacles than the robot itself and able to continue locomotion.
- The cat-leap parkour rolling mechanism allows the soft landing of the robot on the obstacle.
- This mechanism used worm gear, which does not need an external brake and energy while rolling the robot. The cat-leap arm also provides a protective covering, keeping robots safe from high impact forces during landing and unexpected full down or random accidents.

It may be useful in applications like surveillance, military, climbing robot, space exploration mission, etc.

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