Motorola Flash Micro-Controller Design Contest 2003

General Purpose Mobile Robot
TUCATU

Tuba Gümüş

Computer Engineering Departmant

ITU

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GENERAL PURPOSE ROBOT DESIGN AND REALIZATION

(Summary)

The goal of the project is the realization of a low cost, multipurpose robot, named TUCATU. The capabilities of MC6808 such as FLASH, PWM, ADC, multiple interrupts and a large number of I/O pins in a very small package are used as much as possible.

Since being a general-purpose robot, in the scope of this project, some functions are prepared both as hardware and software. The capabilities of TUCATU are:

- Motion
    - Forward
    - Backward
    - Right
    - Left
    - Right forward
    - Left forward
    - Right backward
    - Left backward
- Speed Control
    - Motion speed
    - Steering speed
- Path Measurement
- Steering Angle
- 3 Working Modes
    - Free
    - Training / Teach
    - Playback
- IR Remote Control
- Environment Illumination Level Measurement
- Obstacle Sensing
- Light and Voice Indicator / Alarm

Frame of a 3-wheel cycle is shaped as the body of TUCATU. A DC motor is used for the motion of the robot. An H-Bridge is designed and implemented as the speed drive circuit of DC motor. PWM ability of MC6808 is used for speed control. TUCATU has the ability of speeding up and down.

An optical sensor is attached to the front wheel in order to measure the travelled path. The sensor is designed as simple as possible.

TUCATU contains two stepper motors; one for steering control and second for position control of ultrasonic sensor. For the stepper motors, only a drive circuit is used. Signals for

stepper motors are generated by software. The speed of stepper motors is adjustable and angle of steering can be defined by the user.

TUCATU has three working modes: In free mode, the master may examine the capabilities. In training mode, TUCATU is directed via a TV remote control. The master trains TUCATU. At the end of this mode, she writes the parameters related to her movement to the Flash. In the playback mode, she repeats what she learned. She also will sense the obstacles in front. TUCATU can memorize up to 96 roles, each role has 42 segments.

TUCATU can measure the environmental light level and decides whether or not the headlight is necessary. The light level is measured in analog manner; therefore ADC of MC6808 has been used.

Obstacle sensing system consists of an ultrasonic receiver and a transmitter. The obstacles at the distance of 5-100 cm can be detected by the ultrasonic sensor system. This system is completely a microcontroller based design. Microcomputer generates and transmits 40 KHz signal. The travelled time of the sound which is related to the obstacle distance is measured by computer.

Six LEDs have been dedicated for right and left signals, stop signal and motion indicator. A voice system is used for data entry, data evaluation and alarming.

Besides, it is also possible to transfer data to the robot over IR interface of PCs. So, TUCATU may be used in more extensive projects as a test vehicle. The language which has been developed for TUCATU will be suitable for AI applications.

Contents

GENERAL PURPOSE ROBOT DESIGN AND REALIZATION 3
Contents 5
CHAPTER - 1 7
INTRODUCTION 7
1.1 Document Organization 10
CHAPTER – 2 11
MECHANICAL STRUCTURE 11
2.1 Coupling Elements 16
CHAPTER - 3 .... **Hata! Yer işareti tanımlanmamış.**
ELECTRICAL MOTORS .... **Hata! Yer işareti tanımlanmamış.**
3.1 Main Motor .... **Hata! Yer işareti tanımlanmamış.**
3.1.1 Main Motor Drive Circuit .... **Hata! Yer işareti tanımlanmamış.**
3.1.2 Main Motor Speed Control .... **Hata! Yer işareti tanımlanmamış.**
3.2 Steering Wheel Motor .... **Hata! Yer işareti tanımlanmamış.**
3.3 Ultrasonic Sensor Motor .... **Hata! Yer işareti tanımlanmamış.**
CHAPTER - 4 .... **Hata! Yer işareti tanımlanmamış.**
SENSORS .... **Hata! Yer işareti tanımlanmamış.**
4.1 Path Measurement Sensor .... **Hata! Yer işareti tanımlanmamış.**
4.2 Obstacle Sensor .... **Hata! Yer işareti tanımlanmamış.**
CHAPTER - 5 .... **Hata! Yer işareti tanımlanmamış.**
LIGHT LEVEL MEASUREMENT .... **Hata! Yer işareti tanımlanmamış.**
CHAPTER - 6 .... **Hata! Yer işareti tanımlanmamış.**
ALARMS AND SIGNALS .... **Hata! Yer işareti tanımlanmamış.**
6.1 Signals .... **Hata! Yer işareti tanımlanmamış.**
6.2 Voice .... **Hata! Yer işareti tanımlanmamış.**
CHAPTER - 7 .... **Hata! Yer işareti tanımlanmamış.**
REMOTE CONTROL AND TEACHING .... **Hata! Yer işareti tanımlanmamış.**
7.1 IR Remote Control .... **Hata! Yer işareti tanımlanmamış.**
7.2 IR Transmitter and Receiver .... **Hata! Yer işareti tanımlanmamış.**
7.3 Decoding of IR Remote Control Signals .... **Hata! Yer işareti tanımlanmamış.**
CHAPTER - 8 .... **Hata! Yer işareti tanımlanmamış.**
HOW TO USE TUCATU .... **Hata! Yer işareti tanımlanmamış.**

CHAPTER - 9 .... **Hata! Yer işareti tanımlanmamış.**
SOFTWARE .... **Hata! Yer işareti tanımlanmamış.**
9.1 Operation Modes .... **Hata! Yer işareti tanımlanmamış.**
9.1.1 Free Mode .... **Hata! Yer işareti tanımlanmamış.**
9.1.2 Training Mode .... **Hata! Yer işareti tanımlanmamış.**
9.1.3 Playback Mode .... **Hata! Yer işareti tanımlanmamış.**
9.2 Programs .... **Hata! Yer işareti tanımlanmamış.**
9.2.1 Main Program .... **Hata! Yer işareti tanımlanmamış.**
9.2.2 Motion Motor Program .... **Hata! Yer işareti tanımlanmamış.**
9.2.3 Steering Wheel Motor Program .... **Hata! Yer işareti tanımlanmamış.**
9.2.4 Path Measurement Sensor Program .... **Hata! Yer işareti tanımlanmamış.**
9.2.5 Obstacle Detection Program .... **Hata! Yer işareti tanımlanmamış.**
9.2.6 IR Remote Control Decoding Program ..... **Hata! Yer işareti tanımlanmamış.**
9.2.7 Light Level Measurement .... **Hata! Yer işareti tanımlanmamış.**
9.2.8 Data Entry Programs .... **Hata! Yer işareti tanımlanmamış.**
9.2.8.1 Destination Value Entry .... **Hata! Yer işareti tanımlanmamış.**
9.2.8.2 Step Number Entry .... **Hata! Yer işareti tanımlanmamış.**
9.2.8.3 Motion Speed Entry .... **Hata! Yer işareti tanımlanmamış.**
9.2.8.4 Steering Speed Entry .... **Hata! Yer işareti tanımlanmamış.**
9.2.9 Motion Speed Control Programs .... **Hata! Yer işareti tanımlanmamış.**
9.2.9.1 Speed Up .... **Hata! Yer işareti tanımlanmamış.**
9.2.9.2 Speed Down .... **Hata! Yer işareti tanımlanmamış.**
9.2.10 Stop and End of Segment .... **Hata! Yer işareti tanımlanmamış.**
9.2.10.1 Stop .... **Hata! Yer işareti tanımlanmamış.**
9.2.10.2 End of Segment .... **Hata! Yer işareti tanımlanmamış.**
9.2.11 Flash Erase and Write .... **Hata! Yer işareti tanımlanmamış.**
9.2.11.1 Flash Erase .... **Hata! Yer işareti tanımlanmamış.**
9.2.11.2 Flash Write .... **Hata! Yer işareti tanımlanmamış.**
9.2.12 Teach Mode .... **Hata! Yer işareti tanımlanmamış.**
9.2.13 Playback Program .... **Hata! Yer işareti tanımlanmamış.**
CHAPTER - 10 .... **Hata! Yer işareti tanımlanmamış.**
CONCLUSION AND RECOMMENDATION .... **Hata! Yer işareti tanımlanmamış.**
CHAPTER - 11 .... **Hata! Yer işareti tanımlanmamış.**
REFERENCES .... **Hata! Yer işareti tanımlanmamış.**

CHAPTER - 1

INTRODUCTION

The goal of the project is the realization of a low cost, multipurpose robot, named TUCATU. All abilities of TUCATU are provided by the microcontroller MC6808 of Motorola. The capabilities of MC6808 such as Flash, PWM, ADC and hardware interrupts are used as much as possible. Another objective of this project is to develop basic equipment for AI research on a mobile robot.

Since being a general-purpose robot, in the scope of this project, some functions are prepared both as hardware and software. The capabilities of TUCATU are:

- **Motion** : TUCATU has the following motion capabilities:
  - *Forward*
  - *Backward*
  - *Right*
  - *Left*
  - *Right forward*
  - *Left forward*
  - *Right backward*
  - *Left backward*

- **Speed Control :**
  - *Motion speed:* Speed up and speed down features are provided in forward motion.
  - *Steering speed :* Speed of the steering can be controlled from remote control even if TUCATU is moving.

- **Path Measurement**: The distance related to the trajectory is measured by the optical sensor which has a resolution of 4,41 cm.

- **Steering Angle:** Steering angle is controlled by stepper motor with a gear box. The resolution of the system is 2 steps for 1 degree.

- **3 Working Modes**
  - *Free* : For examination of TUCATU
  - *Training / Teach :* For training TUCATU
  - *Playback :* For TUCATU to repeat what she learnt

- **IR Remote Control:** TUCATU can be controlled by an IR remote control handset which is produced for domestic TV receivers.

- **Environment Illumination Level Measurement**: TUCATU can measure environment illumination level in analog manner.

- **Obstacle Sensing:** TUCATU detects the obstacles front and informs the master.

- **Light and Voice Indicator / Alarm**: Six LEDs have been dedicated for right and left signals, stop signal and motion indicator. A voice system is used for data entry, data evaluation and alarming.

Frame of a 3-wheel cycle is shaped as the body of TUCATU. A DC motor is used for the robot to move. The coupling of DC motor to the front wheel is originally designed and mounted. H-Bridge circuit is designed and used as the speed drive circuit of DC motor. PWM is selected as the speed control method and PWM ability of MC6808 is used.

A stepper motor and a gearbox connected to it are present for the motion of the steering. This design is done by self again. For the stepper motor, only a drive circuit is used. Motion signals are generated by software.

An optical sensor is attached to the front wheel in order to measure the travelled path. The sensor is designed as simple as possible.

The obstacle detection system consists of an ultrasonic sensor connected to a stepper motor and a dedicated circuit. The obstacles at the distance of 5-100 cm can be detected by the ultrasonic sensor system.

TUCATU, as in definition, has three working modes: In free mode, the master may examine the capabilities. In training mode, TUCATU is directed via a TV remote control. The master trains TUCATU. At the end of this mode she writes the parameters related to her movement to the Flash. In the playback mode, she repeats what she learned. She also will sense the obstacles in front. TUCATU can memorize up to 96 roles, each role has 42 segments.

Selection of the modes is provided via an IR remote control, too. RECS 80 standard is chosen for IR communication. The signals coming with this standard are decoded with the required hardware and software.

TUCATU can measure the environmental light level and decides whether or not the headlight is necessary. The light level is measured in analog manner; therefore ADC of MC6808 has been used.

Besides, it is also possible to transfer data to the robot over IR interface of PCs. So, TUCATU may be used in more extensive projects as a test vehicle. The language which has been developed for TUCATU will be suitable for AI applications.

Average load capacity of TUCATU is 40 Kg and maximum motion speed is 0,50 m/s.

During the whole study, mechanical, electrical and electronic designs have been done with the materials we had. Any professional item and help was not involved. From this point, the project may be assumed as an original engineering study and application.

1.1 Document Organization

The project documentation is arranged as below:

Chapter 1 - Introduction
Chapter 2 - Mechanical structure
Chapter 3 - Electrical motors
Chapter 4 - Sensors
Chapter 5 - Light level measurement
Chapter 6 - Alarm and signals
Chapter 7 - Remote control and teaching
Chapter 8 - How to use TUCATU
Chapter 9 - Software
Chapter 10 - Conclusion and recommendation
Chapter 11 - References

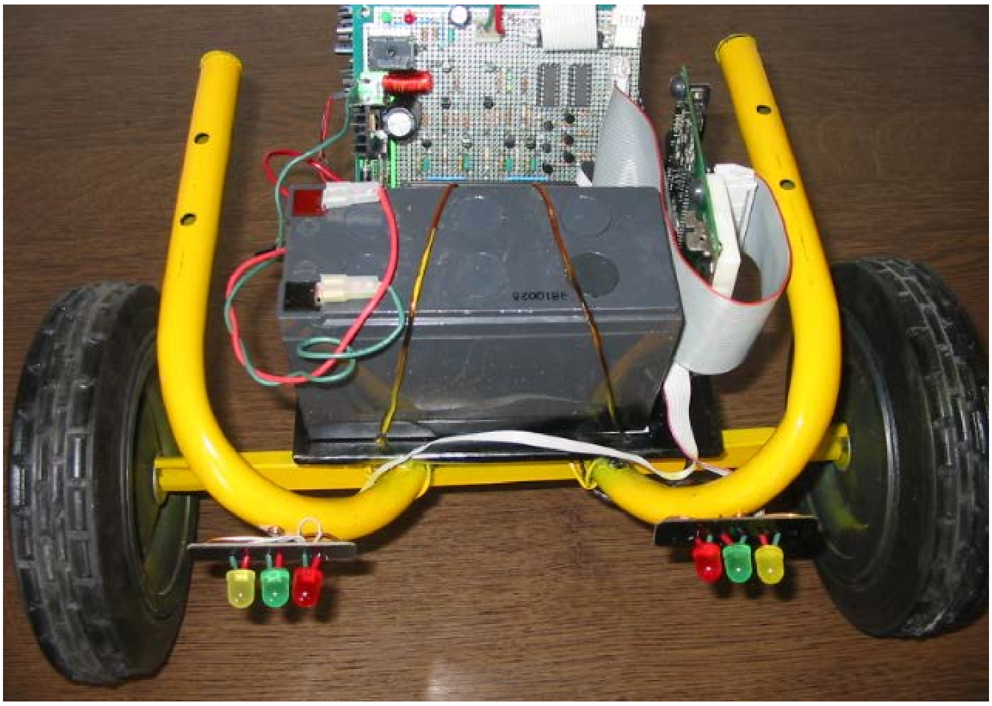
The explanations, drawings and pictures about the subject titles above take place in related chapters.

CHAPTER – 2

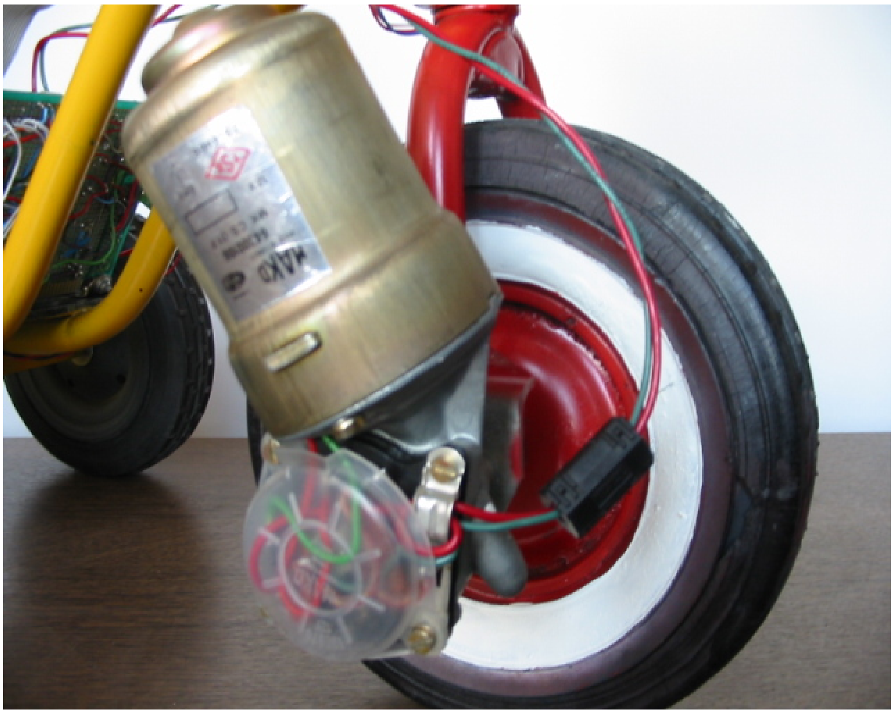
MECHANICAL STRUCTURE

In this chapter, there is information about mechanical design and realization of TUCATU. A 3- wheel bicycle is used as the main part of the robot. Unnecessary parts of the cycle for this project such as pedal and handle bar are cut and the chair is removed. The appending below is done:

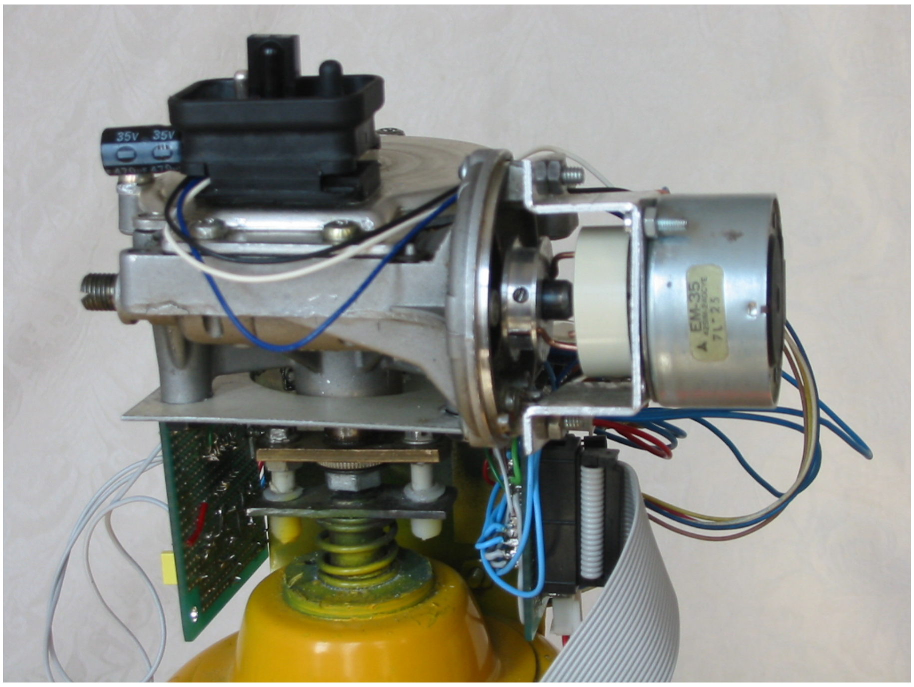
1. The platform where the rechargeable battery, control card and MC6808 are placed. Picture 2.1
2. The motor pedestal providing the movement of the front wheel, Picture 2.2
3. Steering wheel system base, Picture 2.3
4. Ultrasonic sensor and stepper motor base, Picture 2.4
5. Path sensor apparatus, Picture 2.5
6. General-purpose basket, Picture 2.6



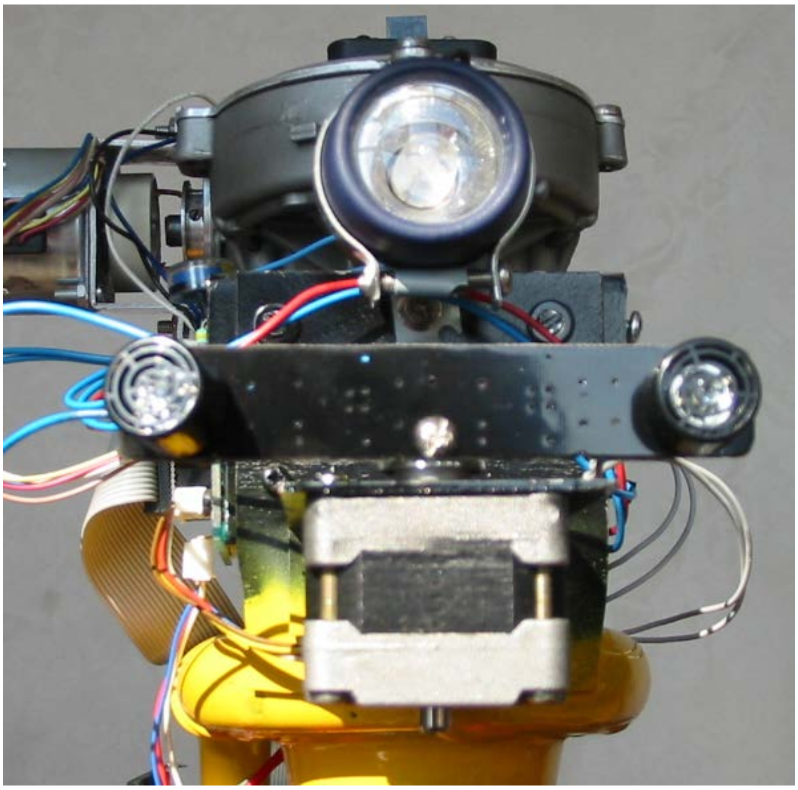
Picture 2.1: The platform where the battery, control card and MC6808 are placed



Picture 2.2: The motor pedestal providing the movement of the front wheel

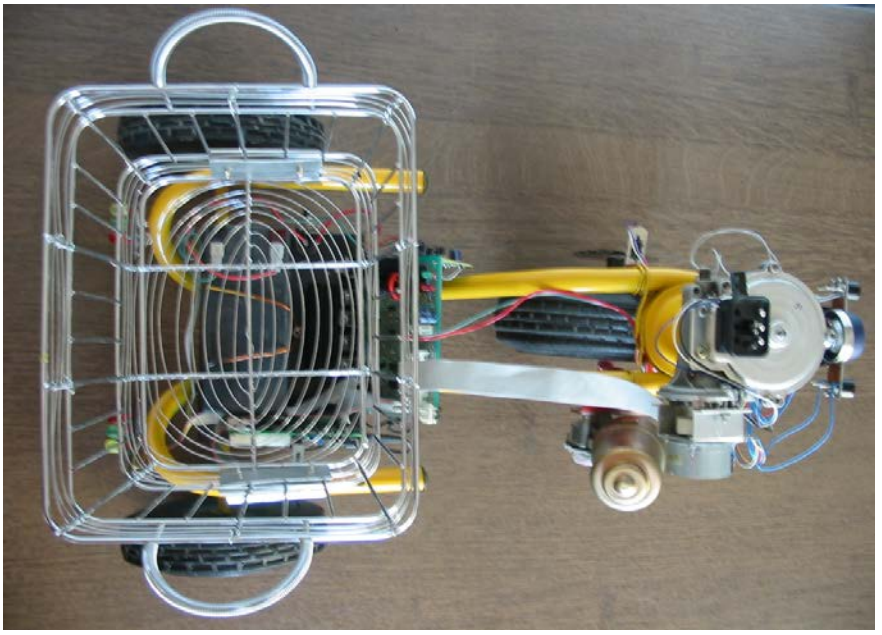


Picture 2.3: Steering wheel system base



Picture 2.4: Ultrasonic sensor and stepper motor base

Picture 2.5: Path sensor apparatus

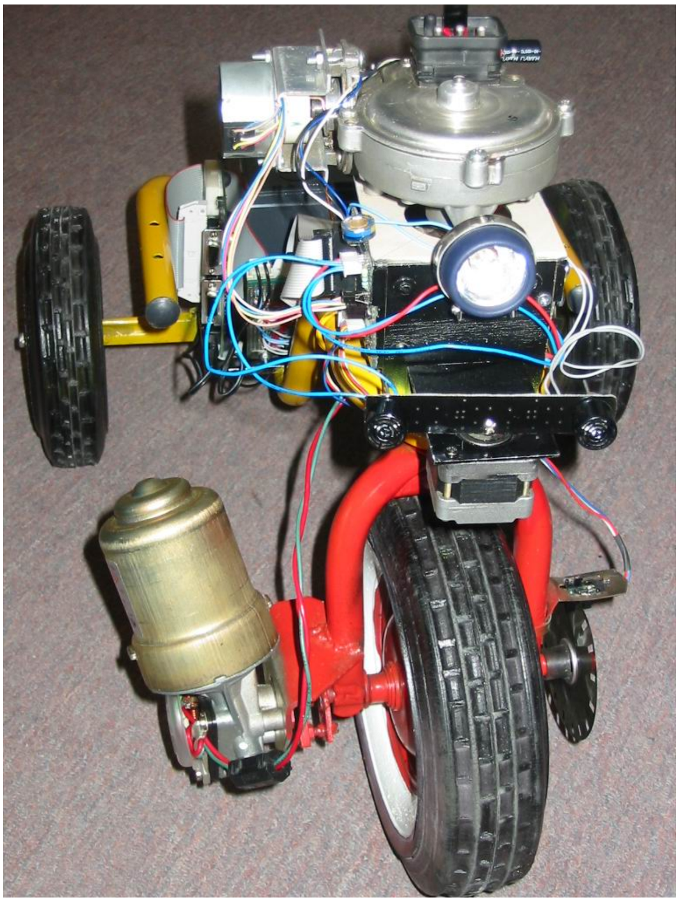


Picture 2.6: General-purpose basket

All necessary mechanical parts mentioned above have been prepared by cutting, bending, drilling, and painting and finally have been mounted. The general view of TUCATU is given in Picture 2.7, Picture 2.8 and Picture 2.9.

Picture 2.7: General view of TUCATU

Picture 2.8: General view of TUCATU



Picture 2.9: General view of TUCATU

2.1 Coupling Elements

The main motion element of TUCATU is a DC motor. An automobile wiper motor is used as the motor. There is an integrated reduction gearbox on the motor. An original coupling element is designed and produced for power transmission from main motor to the front wheel of the bike. This coupling element is shown in Picture 2.8 and the technical drawing is given in Figure 2.1.

Picture 2.10: The coupling element

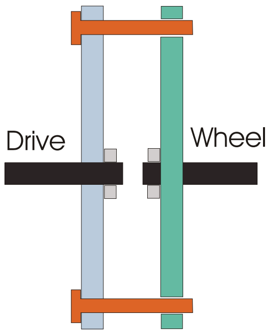
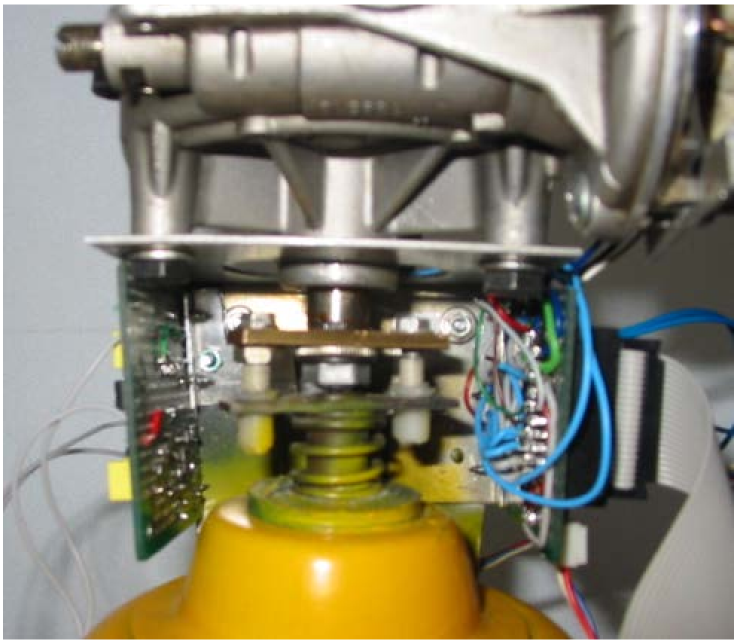


Figure 2.1: Technical drawing of the coupling element

The second coupling element is used for steering wheel system. In this system, a stepper motor taken from an old printer is attached to the handle bar via a reduction gearbox (reduction ratio is 60) of a wiper. The similar coupling elements are used between stepper motor – gearbox and gearbox – handle bar. The pictures of two coupling systems are shown in Picture 2.9 and Picture 2.10 respectively.

Picture 2.11: The coupling between stepper motor and gear



Picture 2.12: The coupling between gear and handle bar