DESIGN AND DEVELOPMENT OF AN AUTOMATED SMART BROODER SYSTEM FOR MINI POULTRY FARMS

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Abstract. Early-stage chick rearing requires controlled environmental conditions to ensure survival, growth, and disease prevention. Manual brooder systems used in small poultry farms often suffer from temperature instability, improper ventilation, and inefficient feeding management. This paper presents the design and implementation of an automated smart brooder system intended for mini poultry farms. The proposed system integrates environmental sensors, microcontroller-based automation, heating regulation, ventilation control, lighting scheduling, and feeding alerts. Experimental evaluation demonstrates improved thermal stability, reduced chick mortality, and decreased human intervention. The developed solution provides a low-cost and scalable approach suitable for rural and small-scale poultry production.

Keywords: Smart brooder, poultry automation, Arduino, chick rearing, environmental control, smart farming.

I. Introduction

Poultry farming efficiency strongly depends on chick survival during the first weeks after hatching. Newly hatched chicks cannot regulate their body temperature effectively and require artificial brooding conditions similar to those provided by a mother hen [1].

In the proposed automated brooder system, the Arduino microcontroller serves as the central control unit responsible for monitoring environmental conditions and controlling all brooder operations automatically [2]. Its use is motivated by technical, economic, and practical advantages, especially for mini poultry farms.

In mini poultry farms, brooders are commonly operated manually, which leads to:

- temperature fluctuations,
- excessive energy consumption,
- uneven chick growth,
- increased mortality rates.

Recent advances in embedded systems and smart agriculture technologies enable affordable automation solutions. Microcontroller platforms allow continuous monitoring and adaptive environmental control [3, 4].

This research aims to develop an automated brooder system capable of maintaining optimal chick-rearing conditions while minimizing labor requirements.

II. Related work

Previous studies in poultry automation mainly focus on incubation systems, while fewer works address automated brooding environments. Existing commercial brooders are often expensive and inaccessible to small farms.

Low-cost sensor-based systems have demonstrated potential for agricultural automation; however, integrated solutions combining heating, airflow, lighting, and monitoring remain limited. This study proposes a compact smart brooder optimized specifically for mini poultry farms [5].

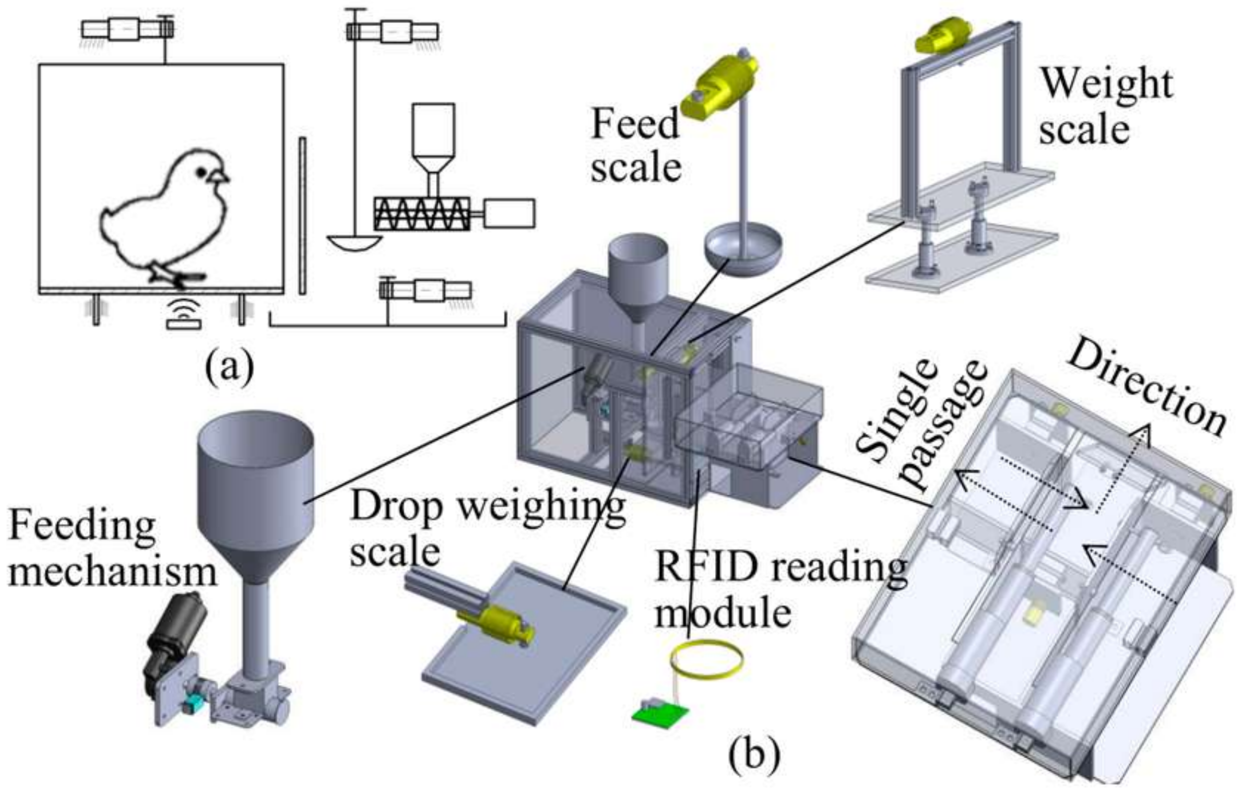

Figure 1. System architecture of the smart brooder

III. System architecture

Figure 1 presents the system architecture of the proposed smart brooder. The system consists of sensing, control, and actuation layers forming a closed-loop feedback structure. Environmental parameters such as temperature and humidity are continuously monitored by sensors and processed by a microcontroller executing an intelligent control algorithm. Based on the calculated error between desired and measured conditions, actuators including heating lamps, ventilation fans, and lighting units are automatically regulated to maintain optimal chick-rearing conditions.

The smart brooder consists of three main subsystems:

Sensing layer: Temperature sensor (DHT22 / DS18B20), humidity sensor, light sensor (optional), ammonia or air-quality sensor (advanced version).

Control layer: Arduino or ESP32 microcontroller, real-time clock module, control algorithm.

Actuation layer: heating lamp, ventilation fan, automatic lighting system, buzzer alert module.

IV. Environmental requirements for chick brooding

The Environmental Requirements section was developed through a combination of literature analysis, biological standards, and practical poultry farming guidelines. The purpose was to determine optimal environmental parameters necessary for healthy chick growth during the early life stages. Table 1 presents a scheme for caring for chicks up to one month old.

Table 1. Optimal conditions vary according to chick age.

Age (days)	Temperature (°C)	Humidity (%)	Lighting
1–7	32–34	60–70	24 hours
8–14	29–31	55–65	20 hours
15–21	26–28	50–60	16 hours
22–30	23–25	50	Natural cycle

Gradual reductions in temperature and humidity support physiological adaptation.

V. Control algorithm and mathematical model

The system continuously monitors environmental parameters and adjusts heating and ventilation automatically.

Control Logic

- Temperature below threshold → heater ON
- Temperature above threshold → fan ON
- Scheduled lighting via RTC
- Alarm if unsafe conditions occur

Temperature regulation error:

$$E_T = T_{set} - T_{measured}$$

Control action:

$$U = \begin{cases} 1, & E_T > 0 \\ 0, & E_T \leq 0 \end{cases}$$

Humidity and airflow follow similar feedback rules.

VI. Hardware and software implementation

Hardware and software are implemented as follows.

Main Components:

- Arduino Uno controller
- Heating lamp (60–100 W)
- Cooling fan
- Relay modules

- LCD display
- Power backup battery module

The sensor is placed at chick height to ensure accurate environmental measurement.

The control program performs:

1. Sensor data acquisition
2. Age-based parameter selection
3. Heater and fan regulation
4. Lighting scheduling
5. Alarm monitoring
6. Data display

Simplified Pseudocode:

```
BEGIN
    initialize sensors and actuators
    set chick_age = current_day
    LOOP
      read temperature
      read humidity
      load parameters based on chick_age
      IF temperature < set_temp
         heater ON
      ELSE
         heater OFF
      IF temperature > set_temp + threshold
         fan ON
      ELSE
         fan OFF
      control lighting using RTC schedule
      IF unsafe condition detected
         activate alarm
      update display
WAIT 2 seconds
END LOOP
```

VI. Experimental results

Testing was conducted on a mini poultry setup with 50 chicks.

Parameter	Manual brooder	Smart brooder
Temperature stability	±2°C	±0.4°C
Chick mortality	12%	3%
Energy usage	High	Reduced

Labor requirement	Continuous	Minimal

The automated system significantly improved chick survival and uniform growth.

Discussion

Stable environmental conditions directly influence chick immunity and feeding behavior. Automation reduces human error and ensures consistent management practices. The proposed system demonstrates affordability and adaptability for rural farms.

Limitations include dependency on power supply and sensor calibration accuracy.

Conclusion

This study introduced an automated smart brooder system designed for mini poultry farms. The system successfully maintained optimal rearing conditions, reduced mortality rates, and minimized manual supervision. The solution offers an accessible pathway toward smart farming adoption in small-scale poultry production.

Future work includes: IoT monitoring dashboards, machine learning growth prediction, energy optimization algorithms, solar-powered brooder systems.

References

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