

Development of Robotic Lawnmower Miimo HRM3000

Susumu OKUBO*

Kenta KAWANISHI*

Makoto YAMAMURA*

Takuya KANISAWA*

Dai HYAKUSAWA*

ABSTRACT

A robotic lawnmower has been developed that mows lawns efficiently and simplifies placement, cleaning, and operation. It uses an efficient method for turning within the mowing boundaries to shorten the time required for mowing.

In addition, in order to facilitate mower cleaning, the robotic lawnmower is the world's first to be given a waterproof frame that is washable with a garden hose.

Also, whereas existing robotic lawnmowers have limited options for where to place the docking station for charging, this robotic lawnmower was enabled with a system for returning to the docking station from any angle in response to user demand for as much freedom as possible in station placement.

Furthermore, the mower has a likable exterior design and can be linked with smartphones.

1. Introduction

Many people perceive mowing as a chore and want a lawnmower that will give them more leisure time.

In 2012, Honda released two robotic lawnmowers: the Miimo HRM300 and Miimo HRM500. They were then remodeled in 2015 and 2016, respectively, and the model names were changed to the HRM310K1 and 520K1 (hereinafter the conventional models).

Since their release, the conventional models have met demand for keeping lawns beautiful without expending the time or effort⁽¹⁾.

In Europe, where robotic lawnmowers are prevalent, competition is fierce. In addition to recent offerings by European manufacturers, Chinese manufacturers have entered the market. Research is also active with multiple studies⁽²⁾.

Honda has newly developed the HRM3000 as a premium model as shown in Fig. 1. This paper will

showcase the features of this model: namely, technology for mowing lawns more quickly; the washable, waterproof structure; technology increasing the freedom of docking station placement; and other new functions.

2. Development Goals

Prior to the development, Honda has conducted European market research to analyze user demands and issues with existing robotic lawnmowers.

The results showed that demand was high for the following four items:

- (1) Shortening mowing times by using the mower body for autonomous lawn mowing (hereinafter the mower) to increase time for tending to flower gardens and plants and playing in the yard with children
- (2) Simplifying the laborious process of cleaning clingy grass from the mower blade area and underside after mowing
- (3) Installing the docking station somewhere inconspicuous to help prevent theft and keep the yard landscape beautiful
- (4) Simplifying the post-purchase configuration procedure and the restarting process when the mower stops unexpectedly or has other issues

Based on the above user demands, the development goals for the HRM3000 were as follows:

- (1) Shorten mowing time from conventional models
- (2) Make mower washable with garden hose
- (3) Increase the freedom of docking station placement
- (4) Simple, easily-understood operation



Fig. 1 Robotic lawnmower Miimo HRM3000

* Power Products R&D Center

3. HRM3000 Configuration and Design

3.1. HRM3000 Configuration

The HRM3000 robotic lawnmower comes with the aforementioned docking station and mower, as illustrated in Fig. 2. The docking station emits various signals, including signals to the boundary wire for setting the mowing boundary and a station signal for giving the position of the docking station.

A structural drawing of the mower is given in Fig. 3, and a specifications comparison with the conventional model HRM520K1 is given in Table 1. The mower comprises a mowing blade motor, motors for driving each of the rear left and right wheels, a trimming height adjustment motor, a battery power source, and a control board to control mower behavior. It also comes equipped with a display for showing device status and inputting mowing settings, as well as an area sensor for sensing the magnetic fields of the boundary wire and station signals. Users can configure and operate the mower via the display or through a smartphone using Bluetooth® wireless communication with the control board. As detailed below, smartphone-only functionality has also been added.

3.2. Design

3.2.1. Basic concept

The basic concept for this model is to clearly promote Honda's brand for robotic lawnmowers. As shown in the

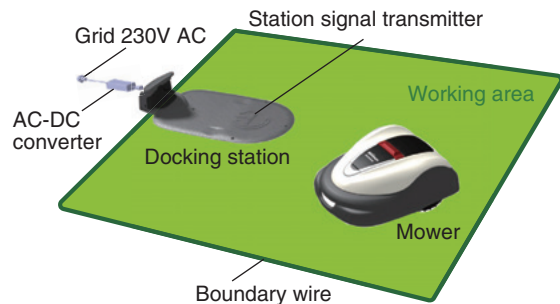


Fig. 2 Robotic lawnmower configuration

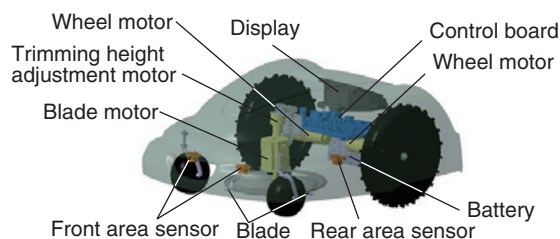


Fig. 3 Mower components

Table 1 Comparison of specifications

Model		HRM520K1	HRM3000
Overall length (mm)		645	710
Overall width (mm)		550	
Overall height (mm)		275	301
Wheelbase (mm)		300	326
Mass (kg)		11.9	13.8
Wheel diameter (mm)	Front	100	
	Rear	200	250
Forward speed (m·s ⁻¹)		0 - 0.55	
Trimming width (mm)		220	250
Trimming height (mm)		20 - 60	
Blade rotating speed (min ⁻¹)		2500	2290
Blade type, Number of blades		Swing-back type, 3 blades	
Motor performance (W)	For driving	10.8 x 2	17.6 x 2
	For mowing	28.8	40.8
	For trimming height adjust	-	3.2
Battery	Type	Li-ion	
	Capacity	22.2V x 3.6Ah	22.2V x 5.4Ah
Sound power level (dB(A))		60.5	59

basic concept illustration in Fig. 4, the product has been designed to promote the luxury of the premium model as sensible added values and to get users to develop an affinity and loyalty in using the product.

3.2.2. Mower design

As factors in increasing human affinity and loyalty to robots, Honda engineers hypothesized that movement and creature-like feel are more important than external shape. Based on this assumption, they focused on producing a creature-like feel with the smooth turning as described in Section 4.1.1. and styled the mower with organic curves reminiscent of that movement as shown in Fig. 1. For coloring, the available colors were based on the conventional models to build the overall brand appeal of Honda's robotic lawnmower line-up.



Fig. 4 Basic concept illustrations

will increase the amount mowed, trimming width was changed from 220 mm for the conventional models to 250 mm. Enlarging the trimming width also allows for the blade speed to be set lower, which reduces noise while also increasing the amount mowed. The results are given in Table 1: The sound power level is kept at or below that of the conventional models.

4.1.3. Results of increased efficiency

The HRM3000 was equipped with the parameters as solved in the simulations and run on an actual lawn. The resulting mower track as observed by motion capture is shown in Fig. 9. The times for both methods in attaining a 95% mowing area coverage matched those in the simulations from Fig. 7, illustrating that the new method can complete the task in a shorter period than the conventional method on a real lawn.

4.2. Washable Mower

If the robotic lawnmower is left to continue autonomous operation, grass trimmings will stick to the underside of the mower as seen in Fig. 10 and require removal. As seen in Fig. 11, washing with a garden hose or other running water source is effective in washing the unit quickly. However, as of 2016, neither the conventional models nor competitor robotic lawnmowers were warrantied to be resistant to running water. Therefore, a boot and waterproof aeration filter were added to the conventional models for a waterproof structure on the HRM3000 as shown in Fig. 12. Furthermore, the trimming height adjustment mechanism was motorized and contained within the waterproof frame to increase water resistance.

With this structure, water resistance as stipulated by international standard IP level⁽⁴⁾ was increased from IPX4, which protects against splashes, up to IPX5, which protects against water jets. IPX4 has been the industry standard for

robotic lawnmowers to date. This makes the HRM3000 the world's first hose-washable robotic lawnmower.

4.3. Docking Station Placement

Various user requests, including theft concerns and preserving the lawn landscape, required docking station placement to be made appropriate for each lawn. Also, it



Fig. 10 Grass trimmings on mower underside

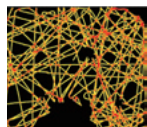


Fig. 11 Washing

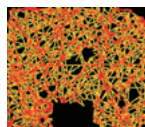
HRM3000



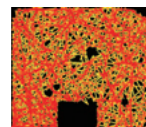
Time : 10 min
Coverage : 12.5%



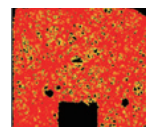
: 50 min
: 49.8%



: 100 min
: 75.5%

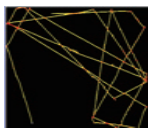


: 150 min
: 86.5%

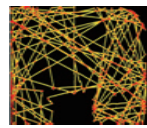


: 240 min
: 95.2%

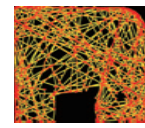
Conventional model



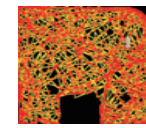
Time : 10 min
Coverage : 11.5%



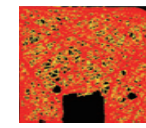
: 50 min
: 43.0%



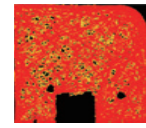
: 100 min
: 65.2%



: 150 min
: 79.7%



: 250 min
: 91.6%



: 330 min
: 95.0%

Fig. 9 Actual mowing coverage observed by motion capture

is important to help ensure that the mower returns to the docking station to charge its battery so that it can continue mowing.

For the conventional models, the docking station could only be placed somewhere parallel to the boundary wire. In response to the user demands, HRM3000 docking station placement options were expanded to include locations perpendicular to the boundary wire, recessed areas, and boundary wire corners as given in Fig. 13.

Expanding placement options for the docking station requires the mower to be able to return to the docking station from any angle. Therefore, a station signal system was applied to the docking station, enabling the mower to detect the station location from any direction.

For the station signal system, a circular wire installed on the bottom of the docking station constantly sends out a uniform magnetic signal to the surrounding area. Fig. 14 depicts the magnetic field generated by the station signal.

When the conventional models return to their docking station, they travel along the boundary wire as shown in Fig. 15. Given the weak range of the station signal's magnetic field, however, the mower can only detect the signal when near to the station and can only approach the station from one direction.

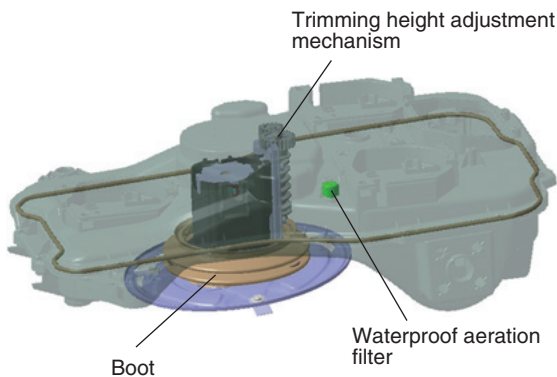


Fig. 12 Waterproof frame

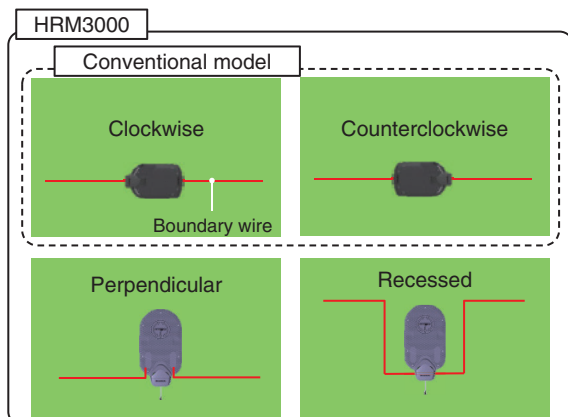


Fig. 13 Docking station placement

When the HRM3000 returns to its docking station, as shown in Step 1 of Fig. 16, it first returns to the boundary wire, then detects the station signal using the front area sensor, and then heads for the center of where the magnetic field is strongest. This allows for the docking station to guide the mower to it from any direction.

Finally, as shown in Step 2 of Fig. 16, in order for the mower to dock with the station's charging terminal, the mower's rear area sensor is used to detect the docking signal. Once the rear area sensor reaches the center of where the magnetic field is strongest, the mower returns to the charging terminal of the docking station. This station signal system has increased freedom in docking station placement.

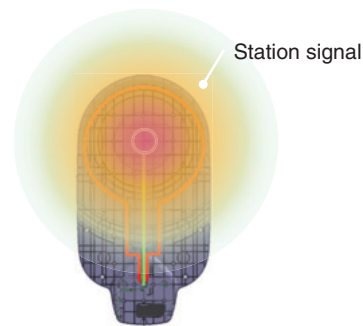


Fig. 14 Station signal magnetic field

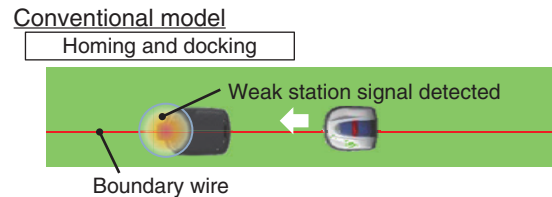


Fig. 15 Docking method of conventional models

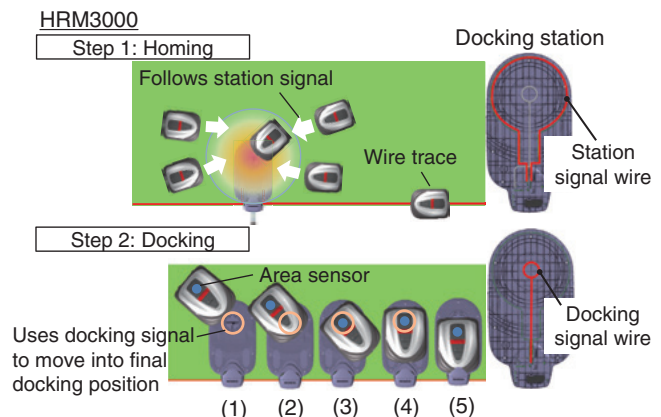


Fig. 16 Driving method when docking

4.4. Smartphone-linked Features

4.4.1. Troubleshooting

With this feature, users can check mower status and find out how to treat any troubles that may arise. As shown in the example given in Fig. 17, the screen displays operations for the user to perform and instructions when they should contact their dealer.

4.4.2. Trouble reporting

As shown in Fig. 18, with this feature, users can use their smartphone to have the mower transmit malfunction history and configuration information to the dealer product diagnostic system⁽⁵⁾ via Honda servers. With the conventional models, users had to call or otherwise tell the dealer when a mower malfunction occurred. The treatment and resolution process could be time-consuming: due to discrepancies between information from the user and reality, the dealer would sometimes have to visit the user's lawn to correctly assess the situation.

By transmitting the malfunction history and configuration information in advance to reveal the real situation, the dealer can guess the cause of and treat the malfunction before ever visiting the user's yard. The system transmits quantitative data, allowing precise information to be shared and analyzed, as well as quick response to the underlying causes.

Window shows user's next operations.

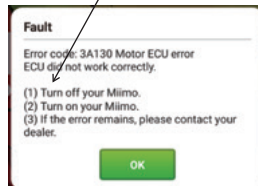


Fig. 17 Troubleshooting example

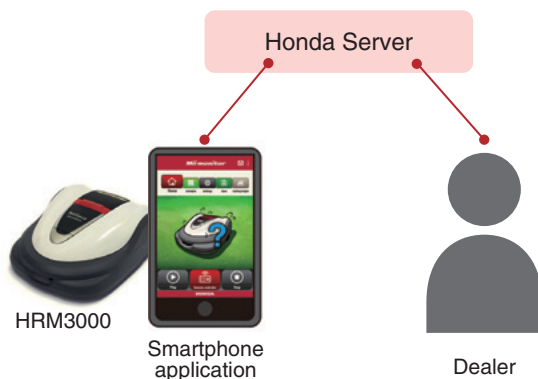


Fig. 18 Trouble reporting system

4.4.3. GUI for the smartphone application

Following with the design basic concept, the graphical user interface (GUI) was designed to be intuitive and build user loyalty.

As given in Fig. 19, current mower status display on the Home screen is animated to add movement and expression so that the user will feel a closeness with the product and intuitively understand the status. Next, as shown in Fig. 20, icons for frequently-used operations are arranged along the top portion of the Home screen, where users view frequently⁽⁶⁾, to increase convenience.



Fig. 19 Status indicators



Fig. 20 Home screen and icon design

5. Conclusion

Honda engineers have developed the following technologies to meet the demands voiced in market research of robotic lawnmower users:

- (1) Smooth turning, to allow for faster mowing
- (2) A waterproof frame, making the mower washable with water
- (3) A station signal system, for increased freedom in docking station placement

In addition, smartphone linking has been enabled to provide a product for simplified configuration and response to any troubles that arise.

References

- (1) Kawakami, T., Kobayashi, H., Yamamura, M., Maruyama, S.: Development of Robotic Lawnmower Miimo, Honda R&D Technical Review, Vol. 25, No. 2, p. 54-59
- (2) Shimamura, H., Matsui, Y., Schmitt, S.: Study of Optimal Operation Control for Robotic Lawnmower, Honda R&D Technical Review, Vol. 29, No. 2, p. 85-89
- (3) European Garden Machinery Industry Federation: EGMF ROBOTIC MOWERS PERFORMANCE EVALUATION STANDARD RLM004-1.0/2016, Clause 4.2
- (4) International Electrotechnical Commission IEC60529:2001, Clause 6
- (5) Dobashi, M., Yamamura, M., Miwa, A., Yamanaka, M.: Diagnostic System for Power Products Using Automatic Recognition Technology for Multi-protocols, Honda R&D Technical Review, Vol. 20, No. 2, p. 96-100
- (6) <https://www.nngroup.com/articles/f-shaped-pattern-reading-web-content-discovered/>, 4/17/2006

■ Author ■



Susumu OKUBO



Kenta KAWANISHI



Makoto YAMAMURA



Takuya KANISAWA



Dai HYAKUSAWA