# Ritchie the DeskBuddy: 3D Printed Robot Avatar for Event Reminding

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## Abstract
Ritchie The DeskBuddy is a 3D printed robotic tiger that works as an ambient device for reminding and notifying users about events relevant to their life. In this project, we attempt a different approach to combine digital information into a physical object, personified by an avatar. Ritchie is a tiger sitting on a car which plays a melody while waving the arms, blinking the eyes and moving around. Through the use of such an ambient device, we seek to be able to drive user reaction and to also form an emotional bond with the user. We also aim that such a device can be used to imbibe new habits in users.

## Author Keywords
Ambient Device; Tangible Interface; Personification; 3D Printed Robots

## ACM Classification Keywords
H.5.2 [Information interfaces and presentation]: User Interfaces

## Introduction
There are a wide variety of resources available to people to keep track of events and activities, to remind them about these, and to make them more productive. Two commonly used approaches are: (a) using physical reminders such as post-it notes and diaries, and (b) using software re-

minders, such as Google Keep and Google Calendar. The drawback of using post-it notes or diaries is that the user is physically constrained. That is, if the user has the post-it notes at home, these notes aren't accessible when they are away from home. On the other hand, while tools such as Google Keep and Google Calendar are available to use for free, these are easy to ignore as they only exist virtually (only provide simple notifications) and are not reflected sufficiently enough in the physical world.

This project attempts a new approach to providing event reminders. What if it were possible for a physical object in a user's space to draw attention and spark user reaction in a more effective manner? What if there could be an object that can play the role of a friend that reminds you about the occurrence of an event? Wouldn't it be great if someone were to tell you to stop whatever you were doing and keep up with your new year's resolution of running a 5K everyday? Graphical User Interfaces, by their nature, do not create an emotional bond with a user in most interfaces. Having an emotional bond with an object can greatly enhance user experience with that particular object, irrespective of the simplicity of its purpose.

Ritchie the DeskBuddy is just the device for the role. Ritchie is a 3D printed robotic tiger that sits on a user's desk and reminds them of events or activities that need to be done. As an internet-connected device, Ritchie can be of great utility when provided with pertinent data sources, such as Google Calendar. To be clear, Ritchie is not an AI (Artificially Intelligent) robot. It cannot tell you what you need to do, or tell you about the weather i.e. it cannot speak. Nor can it specifically remind you to buy some eggs on your way back home. What Ritchie can do is wave its arms and move around to get your attention about something important. This should trigger the user to check the source of this action. The events can range anything from small everyday events to more important things that demand immediate action.

## Related Work

Peek et. al [5] describe *Hangster*, an ambient display that embodies virtual interactions using physical devices hanging on strings. These devices are designed to look like personalized avatars. *Hangster* allows a person to see their friend's status (online/offline) on a messaging application (by lowering/raising the avatar), and allow some simple interactions - e.g. initiate a conversation by gently tugging on the avatar string, show notifications by moving. *Dino*[1] is an ambient display that controls a physical object to react to the nature of conversations on a chat application. By studying the content of the conversation, the 'egg' moves to show whether it is happy, sad, angry or calm. Similarly, *Availabot*[2] is a computer-controlled push puppet that stands or falls down to reflect a friend's availability (online/offline status) on a chat application.

Jafarinaimi et. al [3] describe *Breakaway*, an ambient display that attempts to encourage people who sit for long periods to take more frequent breaks. This is implemented using a shape-changing artistic sculpture object. User's position and posture is tracked using various sensors. Shape and movement of the device reflects the user's pose - upright when the user takes a break, and slouching when the person has been sitting for extended periods. Similar to *Breakaway*, *MoveLamp* [1] keeps track of a person's physical activity at the workplace and attempts to encourage physical activity when a person has been sitting for long periods. This made use of a pedometer application on a

[1] Dino - Ambient Display Creature: https://www.youtube.com/watch?v=AvST9wjrkC4

[2] Availabot: https://www.youtube.com/watch?v=w0voYnEjFcQ

smartphone, in combination with software on a computer to control an ambient lamp that changed color from green to red to make the user aware that they need to move. Rogers et. al [6] investigated whether ambient displays can be used to influence behavioral changes among people. In this study, they installed twinkly lights in the carpets to unconsciously guide people to take the stairs. A large ambient display in the common area was used to visualize the number of people using the stairs vs. those that chose to use the elevator. While each of these were implemented differently, they shared a common goal of nudging a user towards an action and observing common behavioral changes over extended periods of time.

In *Tangible Bits* [2], Hiroshi Ishii proposes the concept of coupling the digital world (bits of information) into a physical object, thereby making it 'tangible'. In line with this concept, Ritchie The DeskBuddy would be a Tangible Bit, where the object would mirror digital information and events, acting as a 'phicon', or a physical icon. *ReaDIYmate*[3] is a commercially available DIY (Do-It-Yourself) kit for building internet-connected paper objects that react to events in the digital world. Similarly, few other devices exist that physically react to digital events and interactions - *Olly*[4] is a device that releases a scent for certain digital events/interactions. Similarly, *Polly*[5] is a device that releases a ball of candy for certain digital events/interactions.

Besides the above mentioned research and projects, there is sufficient work in the area of 3D printed robots and robot parts[4, 7][6] [7], as well as numerous resources for accessing 3D models of robots and parts for 3D printing.

## Project Description

Ritchie The DeskBuddy is a 3D printed robotic tiger that sits on a user's desk and reminds them of events or activities that need to be done.

*Information Displayed*

The device reflects reminders, events and tasks relevant to a user. The same concept can be used to developing and practicing some new habits as well, e.g. reading one chapter of a book everyday, running 5K, practice sketching etc.

*Data Source*

For this project, Google Calendar[8] was used as the data source, as it is already widely used by many users as an application for recording activities and keeping track of events.

*Device Components*

The following components were used to build Ritchie the DeskBuddy:

- Particle Photon;
- 1200mAh Lithium battery;
- Photon battery shield;
- Continuous Rotation Micro Servo;

[3] ReaDIYmate: http://readiymate.com/
[4] Olly: http://www.ollyfactory.com/
[5] Polly project: http://www.ollyfactory.com/polly/

[6] Instructables page: "GearBot: A Dual-speed, Gear-driven robot": http://www.instructables.com/id/GearBot-A-Dual-Speed-Gear-Driven-Bot/?ALLSTEPS
[7] Cubify - Commercial 3D printed parts for custom designed robots: http://cubify.com/store/mrn
[8] Google Calendar API: https://developers.google.com/google-apps/calendar/

- 180deg rotation Micro Servo;
- Accelerometer;
- Piezoelectric speaker;
- White LED.

*Device abilities*
The 3D printed robot will be able to do the following:

- Perform a waving action (arm movement);
- Move on a flat surface (walk/drive);
- Play certain sounds for certain events;
- Blink lights to attract attention.

*Mapping of information to visualization*
The basic device capabilities are:

- Perform a waving action (arm movement):

  The waving arms are controlled using a micro servo motor. The motor pulls a string that connects both the arms of the robot. By alternately pulling and releasing the string, the arms are raised and dropped. Using this mechanism, it is possible to create the waving action in the robot. The visual effect can be seen on Figure 1.

- Move forward/backward:

  The robot uses wheels to move. The forward/backward motion of the robot is performed using a continuous rotation motor, which is used for turning one of the wheels. This is done by creating spokes on one of the wheels, which can be pushed by the rotation motor. Figure 2 shows the mechanism used for producing the movement.

- Play certain sounds for certain events:

  The robot uses a piezoelectric speaker to play melodies during the event-reminding action.

- Blink lights to attract attention:

  A white LED is used to light the robot eyes, again, to attract the user's attention.

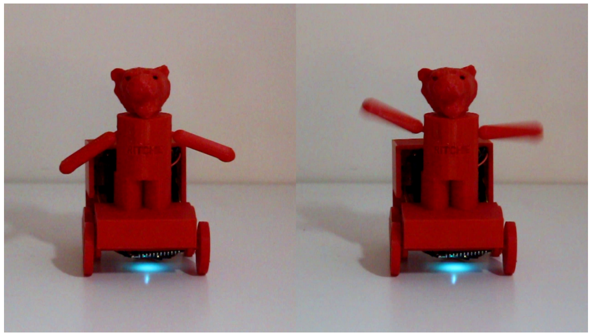

**Figure 1:** Arm-waving movement produced by pulling a string with a servo.

*Design*
All the parts for 3D printing were modelled using TinkerCad[9]. The tiger head for the robot was created by removing the unwanted parts of a Tiger model[10] available for use on the TinkerCad gallery. By modifying this model, it was possible to make the head hollow in order to house the LED

[9] TinkerCad: https://www.tinkercad.com/
[10] Tiger model available on TinkerCad: https://www.tinkercad.com/things/fhidfq2ZhEC-tiger

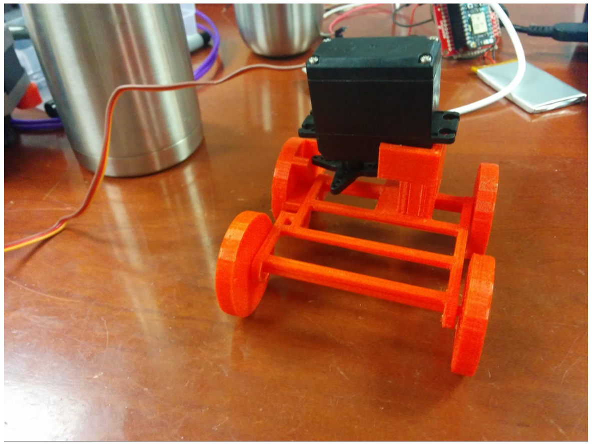

**Figure 2:** Motor used to move the wheel with spokes.

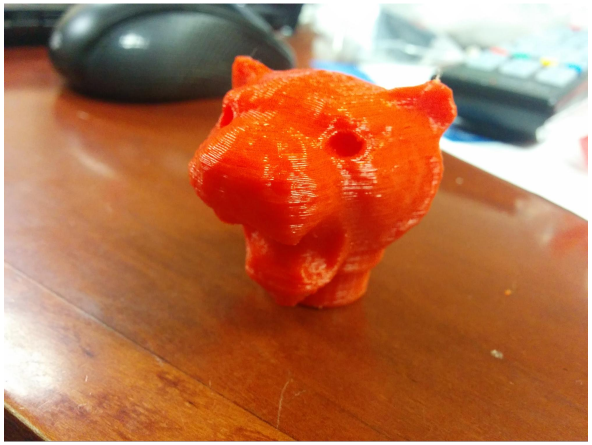

**Figure 3:** 3D printed from modified tiger model.

and the piezo speaker, as well as create eye sockets. Figure 3 shows the resulting 3D printed head.

The main body of the robot was designed to house the head, the arms, as well as cover some of the electronics at the base. Together with a back case designed to look like a jetpack, these parts cover most of the electronics in the robot. The "jetpack" case mainly hides the big motor, the micro servo and the battery. The photon, the battery shield and most of the wires are hidden under the tiger. Figure 4 shows the back case and the battery attached to it and Figure 5 shows the main body.

The base of the device holds the four wheels which allows the robot to move. As mentioned above, one of the wheels is designed differently so that it can be controlled using the continuous rotation servo. Figure 6 shows the base holding together the wheels, the battery shield and the photon.

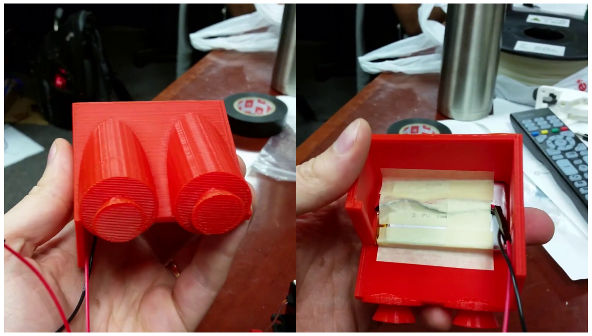

**Figure 4:** Back case designed as a jet pack (left) holding the battery (right).

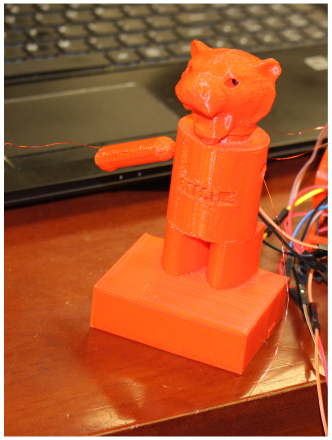

**Figure 5:** Main body with head and right arm.

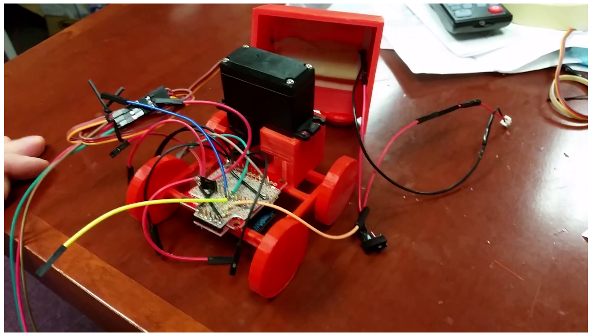

**Figure 6:** Wheels with photon and battery shield.

Lastly, Figure 7 shows the final assembled device.

*Events and Information Visualization*
The current implemented system displays 5 different types of events, with different priorities, using various combinations of the actions described above. The actions for each of the events are specific to each category. In order to identify the various events, we make use of the color tags in Google Calendar, which can be assigned to different events. For each event in the calendar, the only details that are needed by the device are the event color (colorID), and the event start and end time.

Since there are various priority levels involved, it is also important to ensure that higher priority events do not get overlooked as lower priority events in the case of event concurrency. For example, an "Important" event could be overlooked as a "regular" event if the robot performs the action for a regular event. We tackled this by checking for

**Figure 7:** Final assembled product.

concurrent events, so that we ensure that the device behaves respective to the highest priority concurrent event. The actions for each event type are described as follow:

*Important Events*
"Important" events are flagged BOLD RED in the Calendar. The robot displays these events by waving its arms at a preset "high" frequency as well as by moving back and forth at a fast speed. These physical actions are accompanied by flashing the lights in the robot's eyes and by playing the Shave and a Haircut[11] melody specific for this category.

*Alarms*
"Alarm" events are flagged YELLOW in the Calendar. The robot sounds an alarm by playing some preset music. In this implementation, we play the "Nyan Cat" theme song[12].

*Workout*
Since one of the goals of this project is to help users develop new habits, we selected "working out" / "going to the gym" as one of the special use cases of this feature. "Workout" events are flagged GREY in the Calendar. This is visualized by the robot waving it's arms at a preset "medium" speed, as well as by moving back and forth at a slower speed as compared to the "important" events. The robot also flashes its eyes using the LED and plays some music. For the music, we chose to play "Eye of the Tiger"[13] as something that would be motivational and encourage the user to workout.

*Activity/Habit slots*
The "Workout" and "Alarm" conditions are special use cases of this type of event. Users can flag their events PURPLE if they wish to save time for activities such as reading a book, writing a diary etc. These events are represented in the same manner as the "workout" condition. In this condition, the robot plays the "Gonna Fly Now" theme[14].

*Regular Events*
"Regular" events are simply other events from the user's Calendar, but do not require a special action. All colors not used by the above events are considered as "Regular" events. At the start of the event, the robot makes a short beeping sound, and then waves it arms for a short duration. The arm motion is at a slower frequency as compared to the "Activity" event.

All of the above mentioned device actions occur at the start of an event. For the duration of an event, the robot repeats some of the actions at intervals (we have set this interval at 15 minutes), to represent ongoing events. This also meant to act as an ambient reminder. As mentioned above, the robot also moves for some events. This motion is always a preset distance, however, the speed and frequency with which it moves varies for different conditions.

In it's default state, the device does not perform any actions and waits to receive information for the next event.

*User Interaction*
By using an accelerometer, the robot can afford some simple user interactions such as "Tap" and "Shake" gestures. Tap gestures can be used to snooze event reminders from the robot. Once snoozed, the reminder occurs again after 15 minutes. Reminders can be completely blocked for the

[11] Shave and a Haircut, two bits: https://en.wikipedia.org/wiki/Shave_and_a_Haircut
[12] Playing "Nyan Cat" on Arduino: http://www.instructables.com/id/Nyan-Cat-on-Arduino/
[13] Playing "Eye of the Tiger on Arduino: http://forum.arduino.cc/index.php?topic=215687.0
[14] Playing "Gonna Fly Now" on Arduino: http://mleighsmith.tumblr.com/post/116526557727/chill-out-pump-up

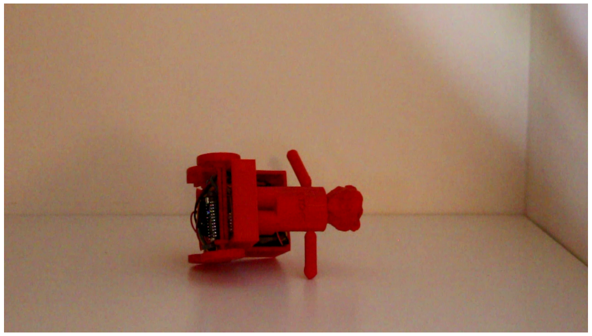

**Figure 8:** Ritchie placed on “Do Not Disturb” position.

duration of the event using a shake gesture. Each user interaction is acknowledged using a beeping sound.

Additionally, the robot can be put in a “Do Not Disturb” mode, by placing it on it’s side. In this orientation, the device will deactivate and no event actions will occur. Figure 8 shows Ritchie on the “Do Not Disturb” position. As a fun addition to the device features, the user can trigger the Nyan Cat music to play by vigorously shaking the device.

## Observations

The first observation from the end-result of this project would be that the robot was much bigger than we had initially imagined. Figure 9 is compares the scale of the robot with other toys that would ideally perform actions such as our proposed device.

The waving-arm motion was not as smooth and exaggerated as initially planned. The mechanism for the arms were planned such that there would be a large arm motion (i.e. the arm motion would span a larger angle).

The flashing lights in the head of the robot are not very

**Figure 9:** Ritchie with other toys for size comparison

bright. This is due to the fact that only one LED was used, which is placed in the center of the head. Also, the holes for the eye sockets are at varying depths, due to the uneven shape of the head model. This causes the light to appear brighter in one eye. We attempted to use aluminum foil inside the head to reflect and amplify the light, but we observed only a marginal improvement.

The micro servo motor, used for controlling the arms, makes a lot much noise. In a way, this is a good thing because this catches the user’s attention well. At the same time, this is a negative effect as it clashes with the music and tones played by the speaker.

## Challenges & Limitations

This project was not short on challenges and every phase of development presented us with interesting obstacles and difficulties. This project encountered all the challenges associated with 3D printing and prototyping - 3D modelling, getting all the object dimensions right and ensuring that all the various parts fit together. Another major challenge was to plan the design before hand, keeping the accommodation of all the electronic components in mind.

As mentioned in the previous section, the final robot was much larger than initially imagined. This was largely down to the use of the continuous rotation servo for moving the robot, which is very big in size. Barring this part, the robot could have been designed to be reasonably smaller.

We observed that the shaking interaction requires a sturdy model, both within and without. Our current model has various separate 3D printed parts, which need to hold together well. Inside the robot some parts, such as the thinner wires broke several times during testing, which is not ideal. It is also really difficult to keep everything (the Particle Photon, the battery shield, battery, piezo speaker, LED, motors and wires) inside the robot, and at the same time have a reasonable size for good user interaction.

We encountered some difficulty with implementing the “tap” detection with our robot. Individually, tap detection using the accelerometer is quite simple as this is managed by a library[15]. However, tap detection in the fully-functioning robot was really tricky - we found that the arm movement would trigger the “tap” function due to the vibrations that it caused. After extensive testing and experimentation, we managed to modify the threshold such that the device would ignore the jolts from the micro servo, yet at the same time reliably detect the tap gestures.

As mentioned in the previous section, the LED lights through the eyes were not as visible as we would have preferred. Although we attempted to use aluminum foil inside the head to reflect and brighten the light, we did not notice any significant improvement.

[15]MMA8452Q Accelerometer library: https://github.com/sparkfun/MMA8452_Accelerometer

## Conclusion & Future Work

The proposed project to build a 3D printed robotic tiger was successfully executed. 3D printing was employed for creating all the parts of the robot. We succeeded in connecting the robot with user data in Google Calendar and produce the desired actions. The robot is capable of representing up to 5 different types of events. The robot allows for user interaction using tapping and shaking.

Despite having successfully executing and implementing the project as per the initial proposal, there is a lot of scope for improvement. In the future, the design for the robot can be improved to ensure that all the electronics components and all wires are completely encased and tucked inside the device. The current design has a gap between the robot and the jetpack which is open and exposes the electronics to some extent. Since this is a working prototype, having that gap helps us monitor the functioning of the various components and fix problems.

We would also like to make the overall device smaller and more compact. We could also create an interface to allow users to customize the robot behavior to their desire within a limited set of parameters (movement speed, movement length, led blinking pattern, melody selection, arm waving frequency etc.) as well as integrate with other services like Gmail, Twitter and Facebook.

It would also be interesting to conduct a study and observe user employment of such an ambient device. Some research questions would be - Do users find it useful to have such an ambient device to provide them with relevant digital information? Does this device make its user more productive? Would users use this robot to set the practice of engaging in new habits such as keeping fit or reading a book? Is such a system an effective method for affecting user behavior? The results of such a study would provide insight into the use of ubiquitous devices for having a positive effect on user behavior.

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