

Conference Paper

Use of *SeedCounter* Mobile App for Wild Species Seed Number Determination: A Preliminary Study

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ABSTRACT

Although its simple nature, seed counting is a crucial but demanding process in seed research and conservation. Manual seed counting, which usually takes a lot of effort and time, needs to be supplemented by new, easy-to-use, and accurate tools to simplify the process. Fortunately, the advance of information technology in recent years is significantly easing daily human life, including seed conservation and research. *SeedCounter* (<https://cutt.ly/xhZFMZk>) is a smartphone app which could help seed scientist to perform their seed counting process. However, as wild plant seeds come in various sizes, forms, and shapes, the app's ability to perform seed count of wild plant seeds need to be understood entirely. Thus, this study aims to understand the *SeedCounter* app's ability to perform seed counting in 20 wild plant seeds collected in Bali Botanic Garden Seed Bank Laboratory. We hope that the study will provide preliminary data for the app's potential to help seed conservation and research future efforts. *SeedCounter* app is downloaded and installed in a Nokia 6.1 Plus smartphone. Seeds photographed using the app with three replications conducted for each of the species. Seed counting is defined as a success if the app can count the seed number three consecutive times correctly. Data analysis was conducted descriptively. The study result showed that the *SeedCounter* app could correctly count seeds of ten plant species, which compares with 50% of the tested species. The result highlights *SeedCounter*'s potential to simplified the counting process of some wild plant species seed.

Keywords: Android, application, seed, smartphone

Introduction

Seed counting is a fundamental process in seed research and conservation. In seed conservation, for example, Millennium Seed Bank Partnership Kew's Germination testing: procedure and evaluation stated that seed number determination of collected seed is the base of whether the seed population is appropriate for germination test as well as its test size (Davies et al., 2015). Meanwhile, in seed research, Germination Percentage (GP) is one of the most used germination parameters. In this parameter calculation, the initial seed number is essential as the dividing factor as GP formula is the number of germinated seed divided by the initial seed number and multiplied by a hundred percent (Kader, 2005).

Despite its importance, manual seed number determination is an inconvenience, while although more convenience, electronic counting device is costly (Liu et al., 2017). The expensiveness of electronic counting devices to simplify the seed number determination process is already experienced firsthand by Bali Botanic Garden Seed Bank as an electronic counting device cost up to twelve million Indonesian rupiahs. The device is also still limited in terms of its counting capability as it is not able to count seed that has a bigger or much smaller size than its aperture. As the machine needs constant electricity input to operate, the machine is limited in terms of its practicality, primarily to be used in the field. Thus, to enhance the seed research and conservation effort, another way to simplify the seed number determination need to be found.

In recent years, the booming of the smartphone has impacted almost every aspect of human life. The smartphone's ability to change people's daily life is due to the device mobile nature. This mobile nature is also supported by the development of many mobile applications (apps) that able

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to help people in their daily life. For example, a smartphone app can improve accident detection and remedy (Patel, 2013). Not only for social service, a smartphone digital calendar app name *RemindMe* is also able to help the senior resident to perform more daily activities (Baric et al., 2019).

The impact of the smartphone is also felt in biological conservation and research. The emergence of plant conservation-related apps such as *iNaturalist*, for example, can enhance herbarium collection research value (Heberling & Isaac, 2018). Some smartphone apps are also able to help plant conservationist and researcher to perform a specific task in their work process. An example of this is found in a mobile app named *ColectoR*, which able to simplify data processing of plant voucher specimens collection (Maya-Lastra, 2016). Not only for voucher specimens collection, android mobile app application named "*Field Book*" is also developed to simplify plant breeding data management (Rife & Poland, 2014).

The smartphone which is usually also equipped with a camera is also able to perform image analysis which able to simplify the measurement process of plant leaf area using a mobile app named *Easy Leaf Area* (Easlon & Bloom, 2014). The image analysis capability of a smartphone is also able to be used grain phenotyping used *SeedCounter* mobile app (Komyshev et al., 2017). Not only *SeedCounter*, Android smartphone-based grain counting, and software is also developed by Liu et al. (2017). These findings highlight the trend of using a mobile device to simplify plant-related works, including seeds or grain counting.

In their evaluation of the *SeedCounter* mobile app, Komyshev et al. (2017) suggest that wheat grain number determination using this app resulted in a very low error value of about 1% mean absolute error and 2% mean absolute percentage error. Another study that utilized image analysis for grain counting is performed in rice by Gong et al. (2018). These research results highlight the possibility to utilized image analysis, which nowadays can perform by smartphone to perform seed number determination of wild plant species. However, as wild plant species come in various sizes, shapes and forms, a study of the mobile app capability to perform seed counting in these plant seed need to be conducted. Thus, we propose this study as a first attempt to evaluate the potential of *SeedCounter* to perform seed number determination of wild plant species. The mobile app is interesting for us as it is freely available and relatively easy to use. We hope that this study will provide preliminary data about the potential use of mobile apps, especially *SeedCounter*, to simplify future seed research and conservation effort.

Material and Methods

Study site

in Bali Botanic Garden Seed Bank Laboratory. The laboratory lighting condition during the data collection is about 216-256 lux. The lighting condition is vital to record as Komyshev et al. (2017) suggest that the lighting condition significantly influences the mobile app's accuracy.

Study material

In this study *SeedCounter*, mobile app version 2.1.4 was downloaded from Google Play Store and installed in a Nokia 6.1 Plus smartphone. A white A4 paper sheet was used as the background and seeds of twenty wild plant species seed collected by the Bali Botanic Garden Seed Bank Laboratory were used as the study object (Table 1). The used seeds are comprising of the display seed, active collection seeds, and seeds that still in the drying process. Thus, the used seed may not currently present on the Seed Bank active collection database. These species were purposively selected to represent the diversity of wild plant species seed morphology. However, we did not use microscopic seeds such as orchids and begonias seeds as the seeds are too small to be observed using the smartphone camera.

Study procedure

For each wild plant species, up to twenty-five seeds were counted manually before used for seed number determination using *SeedCounter* mobile app. During this study, the app default setting was used in seed number determination. The seeds were then placed on a white A4 paper sheet following Komyshev, Genaev & Afonnikov (2017) which suggest that no seed should touch others seed to other seed to avoid counting error. Seeds picture then taken using *SeedCounter* mobile app. Three replications were conducted for each plant species. The number of the app correct and wrong seed number determination noted, and pictures of the counting process saved.

Table 1. Wild plant species seeds name and number used during this study

Plant Species	Seeds Number
Apocynaceae	
<i>Rauvolfia caffra</i> Sond.	25
<i>Wrightia pubescens</i> R.Br.	25
Arecaceae	
<i>Areca vestiaria</i> Giseke	25
<i>Corypha utan</i> Lam.	25
Asparagaceae	
<i>Agave attenuata</i> Salm-Dyck	25
Cupressaceae	
<i>Hesperocyparis lusitanica</i> (Mill.) Bartel	25
Dilleniaceae	
<i>Dillenia serrata</i> Thunb.	25
Elaeocarpaceae	
<i>Elaeocarpus grandiflorus</i> Sm.	25
Euphorbiaceae	
<i>Acalypha spiciflora</i> Burm.f.	25
Fabaceae	
<i>Abrus precatorius</i> L.	25
<i>Biancaea sappan</i> (L.) Tod.	25
<i>Canavalia rosea</i> (Sw.) DC.	25
<i>Gleditsia assamica</i> Bor	25
<i>Guilandina bonduc</i> L.	24
Juglandaceae	
<i>Engelhardia spicata</i> Lechen ex Blume	25
Poaceae	
<i>Coix lacryma-jobi</i> L.	25
Podocarpaceae	
<i>Dacrycarpus imbricatus</i> (Blume) de Laub.	25
Primulaceae	
<i>Ardisia crenata</i> Sims	25
Sapindaceae	
<i>Acer laurinum</i> Hassk.	25
Theaceae	
<i>Schima wallichii</i> (DC.) Korth.	25

Data analysis

Seed number determination was considered as success seed number determination if the app were able to correctly count the seed number in all of the tree replication. On the other hand, the seed number determination considered as failed if the mobile app were not able to count seed number in all of the three replications correctly. The acquired data were then descriptively analyzed and presented as pictures and graphs.

Results and Discussion

During this study, the *SeedCounter* mobile app was able to determine the seed number of ten wild plant species. This number is comparable with half of the all plant species used in this study (Figure 1.). The plant species and picture of seed with success seed number determination presented in Table 2. At the same time, plant species with failed seed number determination presented in Table 3.

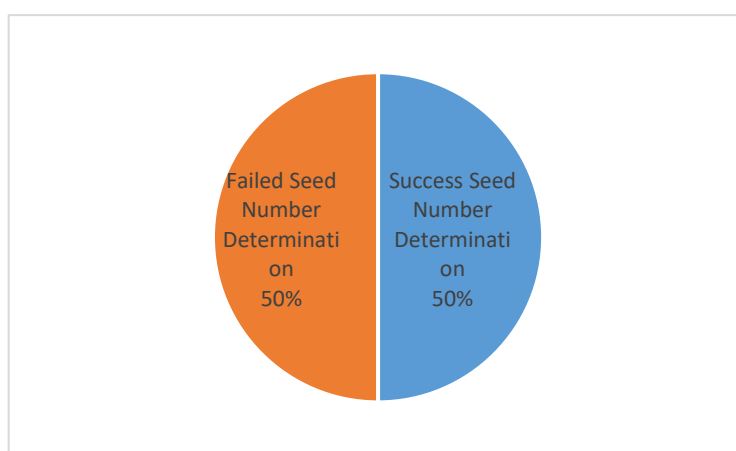

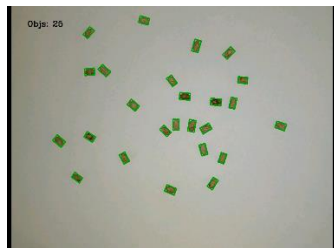
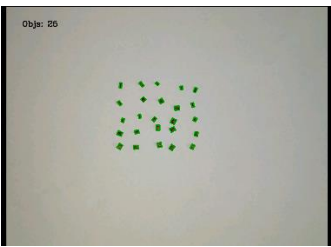
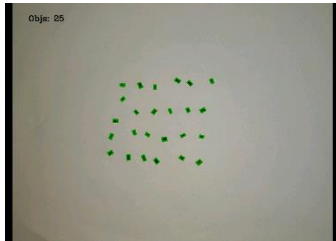
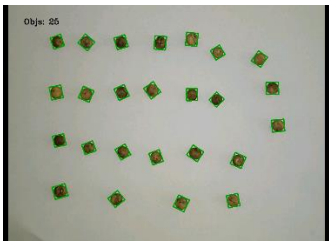
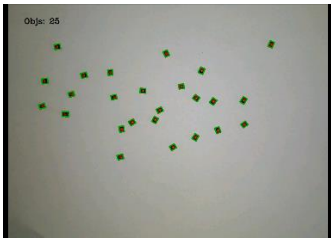
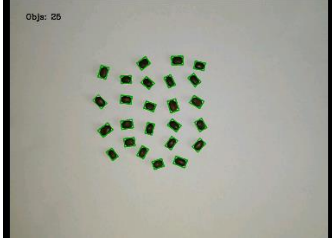
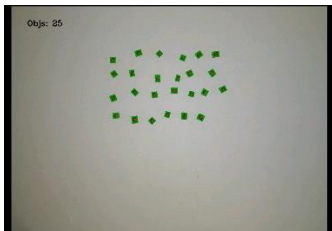


Figure 1. Percentage of plant species with success and failed seed number determination by seedcounter mobile app.

Table 2. Plant Species with Success Seed Number Determination using *SeedCounter* Mobile App.

Species Name	Pictures
<i>Wrightia pubescens</i> R.Br.	
<i>Rauvolfia caffra</i> Sond.	
<i>To be continued</i>	

<i>Hesperocyparis lusitanica</i> (Mill.) Bartel		
<i>Dillenia serrata</i> Thunb.		
<i>Acalypha spiciflora</i> Burm.f.		
<i>Abrus precatorius</i> L.		
<i>Gleditsia assamica</i> Bor		
<i>Dacrycarpus imbricatus</i> (Blume) de Laub. <i>To be continued</i>		


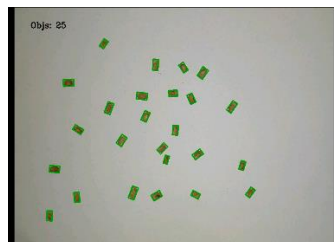

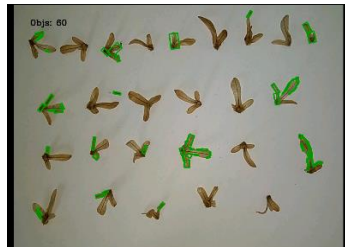

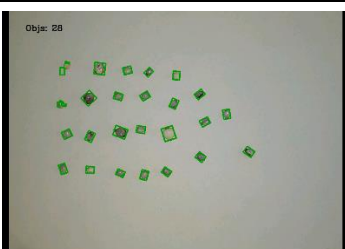
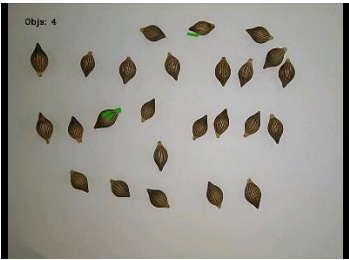
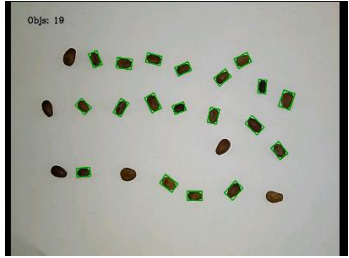
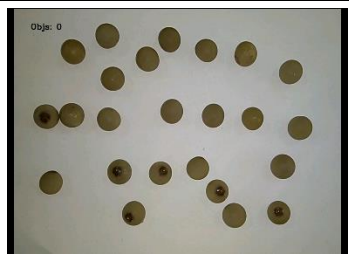
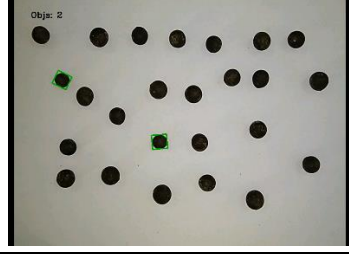
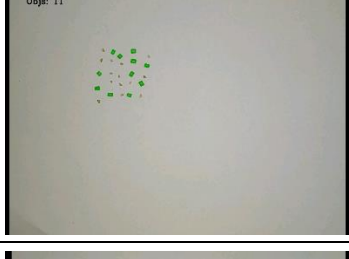

<i>Ardisia crenata</i> Sims	
<i>Schima wallichii</i> (DC.) Korth.	

Table 3. Plant species with failed seed number determination using *SeedCounter* mobile app

Species Name	Pictures
<i>Elaeocarpus grandiflorus</i> Sm.	
<i>Engelhardia spicata</i> Lechen ex Blume	
<i>Acer laurinum</i> Hassk.	
<i>Coix lacryma-jobi</i> L. <i>To be continued</i>	

<i>Areca vestiaria</i> Giseke	
<i>Canavalia rosea</i> (Sw.) DC.	
<i>Guilandina bonduc</i> L.	
<i>Corypha utan</i> Lam.	
<i>Agave attenuata</i> Salm-Dyck	
<i>Biancaea sappan</i> (L.) Tod.	

This study result showed that seeds with successful and unsuccessful seed number determination come from various shapes. The spherical seeds such as *A. precatorius*, *D. imbricatus* and *A.*

crenata showed successful seed number determination while other spherical seeds such as *G. bonduc* and *C. utan* showed unsuccessful seed number determination. Meanwhile, the unsymmetric seed shape of *D. serrata* and *A. attenuata* are producing successful and unsuccessful seed number determination results. These results point out that seed shape seems to not correlate with the app's capability to perform seed number determination.

Seed size also seems not affected *SeedCounter* mobile app's capability to determine seed number. Although the app failed to determine a small *A. attenuate* seed number, the app can successfully determine the *H. lusitanica* seed number, which has a comparable size with *A. attenuate*. The mobile app was able to successfully counting *G. assamica* seed numbers but failed to count the seed number of *C. rosea* and *B. sappan* which have comparable seed sizes and shape to *G. assamica*.

This study result showed one reason that probably contributes to the mobile app's inability to perform successful seed number determination is due to the app image analysis failed to detect the seeds correctly. As the app is based on image analysis, failure in this process will indeed affect the app's ability to perform seed counting. The image analysis failure made the app unable to differentiate the seeds and the non-seed in the picture. In *E. grandiflorus* seed number determination, for example, the app is mistakenly counting *E. grandiflorus* seed coat spines instead of the seed itself. Thus, it made the seed number determination result much higher than the actual seed number. The same mistake is also observed in seed number determination of *E. spicata*, *A. laurinum*, *C. lacryma-jobi*, and *A. vestiaria*.

Another image analysis-related error that probably contributes to the app's failure to perform seed counting is the app's inability to detect seeds in the picture. During this study, this kind of error made the app only counting some tested seeds and ignore other seeds in the picture such as observed in seed number determination of *C. rosea*, *C. utan*, and *A. attenuate*. Meanwhile, in seed number determination of *G. bonduc* and *B. sappan* the app is entirely unable to detect the seeds.

Based on this study result, *SeedCounter* mobile app proved to have the potential to simplify the seed number determination of wild plant species. However, as this study is still minimal, it is not able to fully understand the potential of the mobile app to simplify the seed counting process. Nevertheless, this study can provide preliminary data for the opportunity of using a mobile app, especially *SeedCounter* to perform wild plant species seed counting. Thus, further research with more diverse seed morphology and study condition to fully understand this app effectiveness for wild plant species seed counting. Further research in image analysis algorithm may also be conducted as research and finding in this subject is still continuously happening, such as the one conducted by Neilsen et al. (2017).

Conclusion

The *SeedCounter* mobile app can perform the seed determination number of ten wild plant species seeds. This number is comparable with 50% of all tested plant species. Error in image analysis probably the reason for the app's inability to perform successful seed number determination. Further study needs to be conducted to fully understand the mobile app's effectiveness to perform counting of wild plant species seed. However, this study result showed that *SeedCounter* mobile app is the potential to be used to simplify the seed counting process of some wild plant species seed.

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