Private Simple Databases for Digital Records of Contextual Events and Activities

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Abstract.

Farmers' commitment and ability to keep good records vary tremendously. Records and notes are often cryptic, misplaced, or damaged, and for many, remain unused. If such information were recorded digitally and stored in the cloud, we immediately solve some access and consistency issues and make this data FAIR (findable, accessible, interoperable, reusable). More importantly, interoperable digital formats can also enable mining for insights and analysis in both simplistic (sorting or filtering) and complex (multifactor analysis on yields, harvest date projections, etc.) manners.

In this work, we offer well-structured private database templates as open-source resources for agriculturalists who may have modest spreadsheet skills. This approach yields more consistent data with simple entry. These templates are also packaged with a "Simple Personal Databases" workshop that teaches how to build an activity or event log from scratch. Applications include records of field activities, horticultural crop operations, machinery maintenance and repair, livestock treatments, grain marketing and delivery, Food Safety Modernization Act records, and more. These farmer-centric Airtable databases use simple, data-validated forms that are mobile-friendly to yield operational data that is tidy, human-readable, readily edited, and exportable for analysis in other software. The leveraging of data validation with the capacity for complete file uploads, photos, or screen captures helps to keep more complete records in tidy format.

These private databases can fill a gap left by farm management information systems and original equipment manufacturer platforms by easing the collection of data humans know but is often not recorded. Such data can facilitate logistics, provide important contextual metadata for

other data layers, and improve enterprise financial analysis. Data mining, artificial intelligence, and machine learning require the full context of production details (both in cropping and livestock systems) which could be readily collected at the time of operations via simple forms that populate carefully designed databases.

Keywords.
Context, Cropping, Database, Farm Management, Metadata, Record Keeping, Tidy Data.

Introduction

Precision agriculture is undoubtedly data dependent. Analysis of effects requires adequate context, including the backstory and historical conditions specific to the site and season. In addition, modeling, whether biophysical, artificial intelligence, or a blend of the two, is being increasingly used to improve decisions. Those models require data that might not be available from technology built into the equipment or farm management information systems (FMIS; Antle et al., 2017). Furthermore, whether for carbon credits (Illinois Soybean Association, 2022) or other attribute tracking (organic, GMO-free, etc.), much of the data needed may not be included in FMIS or other existing data platforms.

Farmers, equipment operators, and researchers vary tremendously in their approaches to keeping such records. With a blend of dashboard notebooks, receipts, sticky notes, text messages, photos, etc., perhaps the story could be retold, but not without great difficulty and likely some missing pieces. As Pagano et al. (2013) noted, data collected in a plethora of approaches makes it difficult to interpret.

The tracking of product inventories, labor usage, machine time, fuel, and other cropping system inputs requires some means of data collection. A simple system with digital data flow can enable managers (and/or their advisors) to apply simple data science skills such as sorting, filtering, and perhaps using pivot tables or other summation and aggregation tools. Since most agriculturalists are familiar with spreadsheets—at least in use, if not programming them—then it should be a natural step to utilize simple and private databases.

A private database that is well designed and appropriately simple can facilitate improved records that are more handily collected, more complete, and of practical value in near term (tactical) and longer term (strategic) decision making. When connectivity allows, an in-cloud option can quickly address the aspects of findable, accessible, interoperable, and reusable.

With the overall goal of encouraging farmers, researchers, agribusinesses, and advisors who are new to digital records to see how easy it is to “own it” themselves, the specific objectives of this paper and the associated poster are:

1. Explain the concept and key features of simple private databases.
2. Illustrate applications of private databases.
3. Point to concise training resources.

Concepts and Features of Private Databases

Databases are simply collections of logically related information organized so it can be accessed, managed, and updated with appropriate control. There are various types of databases, such as relational, distributed, and graph; some are structured and some unstructured. In this work, we introduce a simple relational database applicable to many agricultural and small business records. This approach is particularly fitting with event or activity type records (who, what, where, when, how much, etc.) that should be kept because the information is useful. This approach yields structured data that is tidy (Neo, 2020). The tidy data will be in a tabular format where each row is an observation (record) and each column is a different variable. Each cell, then, contains a single individual value. These values can be of many data types including dates, integers, real

numbers, hyperlinks, text, or complete documents such as photos. When the data is structured in this tidy format, use of filtering, sorting, aggregation by pivot tables or computing derivatives via software is straightforward.

The reasons this work is based on Airtable (www.airtable.com) include a free tier level of usage, a very mobile-friendly app-like form for data collection, cloud storage, and easy access control. It is cloud-hosted and there are native apps for iOS and Android. As with other cloud services, sharing has assorted levels of security permissions including owner/creator, editor, commenter, or read only.

Much like spreadsheet workbooks with multiple sheets, in Airtable, a database (base) may have multiple tables (lists). Proper planning toward the data collection can greatly streamline the filling of forms (Chen et al., 2010). Even without AI, the use of forms that have data validation, default settings, and smartly re-ordered options can improve accuracy. Data validation ensures consistency in formatting, spelling, and distinction within any data element and makes filling forms easier. Data validation can be implemented using single or multiple selection lists, links to other tables (that list options for choosing), or data types. Using a list, for example, improves both the user experience and data quality. It is quicker and more accurate to select “Bill Waters” from a list rather than type out the name – especially if someone might refer to him as William Waters, Will Waters, or just enter the last name of Waters.

Conditional data requests are simple to implement into the forms. For example, you would only ask for a seed variety and rate when planting or only ask for a destination and amount if you were transporting a commodity. The conditional requests make the forms concise and directly applicable to each situation with less user overload for data entry. Data requests can be required (such as date and operation) or optional (such as a note or photo).

Data in an Airtable database can be downloaded as comma-separated values (CSV) files. Alternatively, you can automate the movement of Airtable form data directly to a Google Sheet. With this approach, you can more directly automate the analytics via pivot tables, sharing with trusted collaborators, etc.

Each Airtable form has a unique URL that would be shared with all who may be called upon to provide data. These forms can be generated without any coding and the URL can be saved as a desktop icon on mobile devices for convenience. They could also be represented as QR codes on pieces of equipment or facilities where key activities occur.

Applications of Private Databases

Digital Field Records

A direct application to precision agriculture would be the recording of each field activity or event. One simple and private database could be used to record every scouting event, UAV flight, or machine pass over a field or management zone. While OEM equipment and FMIS systems might capture as-applied or yield maps, much of the other information that was only known to a human may be lost. In the simplest case, a digital field records database would be for a single farm which may have many fields and crops (grain, forage, specialty). The database could be used to track product movement and delivery as well (such as 1100 bu corn harvested on 10/20/2023 moved from field 1 to bin 7).

Figure 1 illustrates the form from an open-source digital field records template available for anyone to replicate (Buckmaster, 2022). One would simply duplicate the base, then customize the data validation lists, set access permissions, and share the form with appropriate individuals (Airtable, 2022). How to do this is explained via video tutorial links in the reference. The data validation lists include fields/plots, operators, operations, power units (things with engines and traction), implements/attachments (things carried, pushed, or pulled by power units), seeds,

products, fertilizers, and destinations. Date and several data elements are required for submitting a record, but some items (e.g., notes, photo) are optional. This form includes

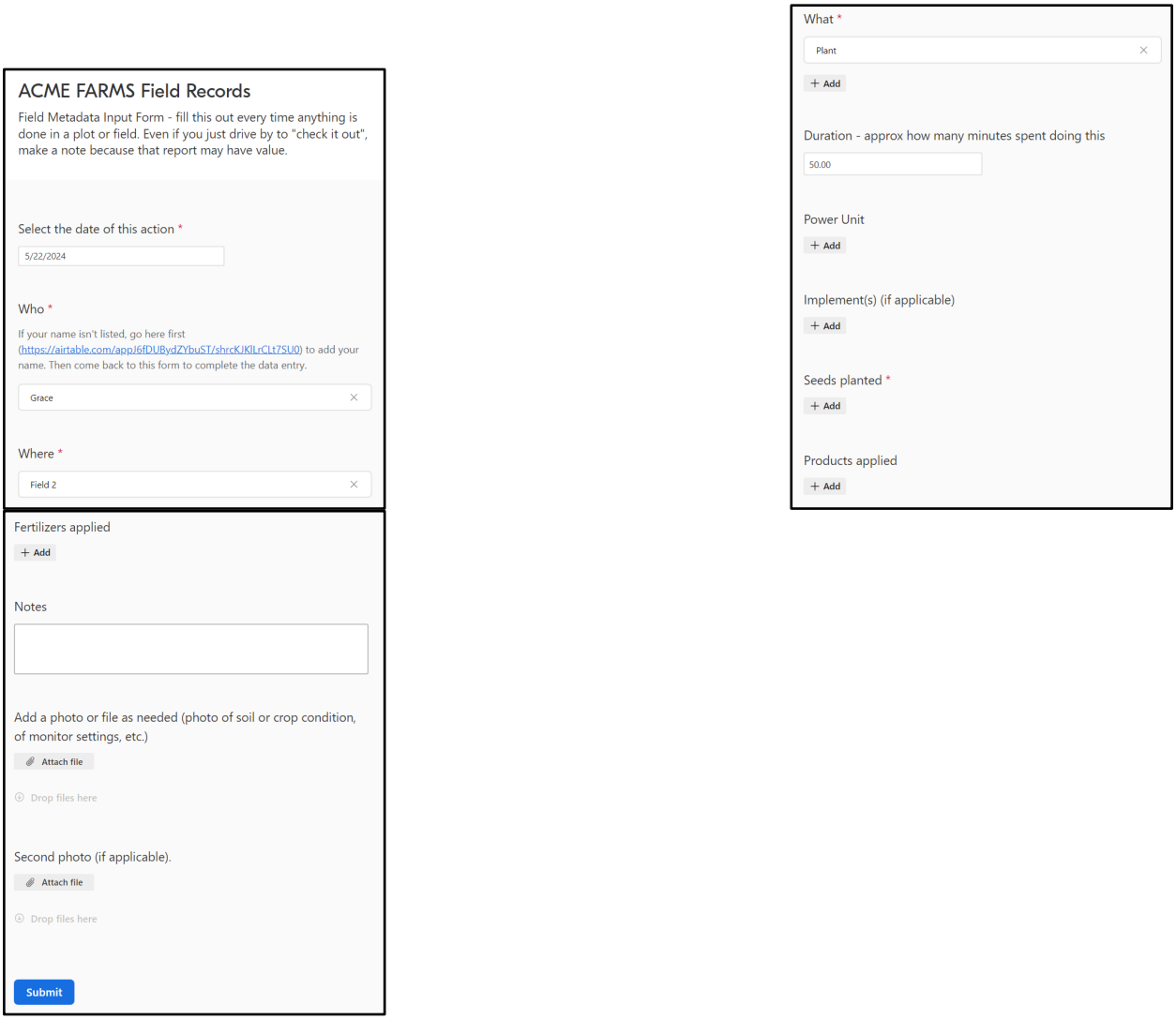

Figure 1. Sample of a partially completed, mobile-friendly Airtable form for recording field activities. Note: conditional data elements are based on the operation (planting, in this example).

conditional data requests that depend on the operation (the “what”) where choices include scout, tillage, plant, harvest, spread/spray, and transport. Figure 2 illustrates the type of tidy data resulting from the completion of the forms over time. With just filtering and sorting, you can get the full record by field, plot, or management zone.

Date of this action	Who	Where	What	Duration	Power Unit	Implement(s)	Fertilizers applied	Fertilizer Rate (lb/ac)	Amount transported	Units of transported product	Destination	Notes
4/1/2023	Joe	Field 1	Spread/Spray	30	Mid-size tractor	fertilizer spreader	46-0-0 urea	100				
5/15/2023	Bob	Field 1	Harvest	90	Mid-size tractor	11 ft mower-conditioner						
5/18/2023	Joe	Field 1	Harvest	75	Mid-size tractor	twin rake						a couple rake teeth missing
5/19/2023	Joe	Field 1	Harvest	60	Mid-size tractor	large round baler			20	Bales	Barn 1	
6/30/2023	Bob	Field 1	Harvest	100	Mid-size tractor	11 ft mower-conditioner						
7/3/2023	Joe	Field 1	Scout	20								it's going to rain, but the hay is not ready. We have to wait
7/5/2023	Bob	Field 1	Harvest	80	Tractor 2 JD X120	tedder						tedder
7/6/2023	Joe	Field 1	Harvest	50	Mid-size tractor	twin rake						
7/6/2023	Joe	Field 1	Harvest	70	Mid-size tractor	large round baler			20	Bales	Barn 2	mediocre quality - some rain

Figure 2. Screen capture of a sample of tidy data (filtered to show Field 1 and sorted by date) of field activities critical to later analysis of weather and management decisions.

For those producing specialty crops in fields, orchards, beds, high tunnels, or even controlled environments, the horticultural crop activity records template might be more applicable than the digital field records (Buckmaster, 2023a). This template includes a few more operations and plant maintenance activities typical of those production systems.

Grain Marketing and Delivery Records

Marketing grain profitably is complex. With hedge-to-arrive, basis, and forward contract options and then delivery that can be tied to a previous contract, deferred pricing, or spot pricing, tracking previous commitments and deliveries can be a challenge. The open-source grain marketing and delivery records Airtable template (Buckmaster and Soonthornsima, 2022) is preconfigured with the contract types and delivery options (source and destination). As with digital field records, simple lists (of contract maker, commodity type, delivery locations, contract type, delivery driver, delivery trailer/wagon, etc.) can be customized for any farm. These digital records facilitate the next marketing decision and the reconciling of deliveries to contracts.

Other Miscellaneous Farm Databases

While the digital field records, horticultural crop activity records, or grain marketing and delivery records databases are most directly applicable to precision agriculture operations, there are many other applications for farms and agribusinesses. With a similar structure, we have seen farmers and farm workers construct databases related to:

- Livestock treatment records
- Farm income and expenses (simple custom accounting)
- Vegetable records and scouting
- Specialty crop deliveries
- Vehicle repair, maintenance, and operational expenses
- UAV logbook
- Crop yield and yield calibration
- Business service records
- Irrigation records

Those producing food crops must keep certain Food Safety Modernization Act records (FDA Food Safety Modernization Act, 2011). A toolkit that “covers the bases” and makes these records more streamlined is also available (Buckmaster et al., 2022).

Available Training Resources

The references cited related to the templates mentioned each include a series of short tutorial videos illustrating exactly how to duplicate and customize each template. These are each less than 60 minutes. For those wanting to build other databases, a recorded workshop, during which users will build an income and expense tracker, is available to show how to craft an activity or event database from scratch (Buckmaster, 2023b). Wiginton (2022) is also a good resource for

Airtable database examples and tutorials.

Conclusion

Full contextual metadata or backstory is required to fully utilize precision agriculture data toward an optimized future. A simple means of capturing this is through private databases. The digital field records template in Airtable is a good starting point for database novices who have a working understanding of spreadsheets. This database structure enables easy and complete capture of field activity and event records in a tidy format that is readily sorted, filtered, and analyzed with spreadsheet software. Similar agricultural records could be kept in databases, and these do not require extensive data science knowledge nor coding skills to tailor them to specific operations or needs.

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