The Possible Use of Point Clouds in A Land Registry System, an Exploratory study

Tom WORTEL and Koen HUISSTEDE, the Netherlands

Key words: Land registry, Point cloud, Digital transformation, legal certainty, boundary determination

SUMMARY

The Dutch Land Administration Office, named Kadaster, investigates the possible use of point clouds in the process of determination of parcel boundaries. The current process has a number of limitations. The most important of which is the lack of transparency for the stakeholders. This lack of transparency leads to a lack of understanding of the process and could lead to a believe that legal certainty is at stake.

The hypothesis is that the use of point clouds can result in a better understanding of all participants in the process. The trust in legal certainty will increase, and stakeholders will feel included in the process of parcel boundary determination.

With a combination of terrestrial LiDAR scans, airborne LiDAR scans and photogrammetric point clouds, a digital twin of the physical situation is created. We experiment with this digital twin in the interaction between parties (citizens and employees of companies) to determine the location of new parcel boundaries. In order to keep the process as simple as can be, interaction takes place in a web-app specifically designed for this process. In this paper we present the intermediate results of this ongoing research.

The Possible Use of Point Clouds in A Land Registry System, an Exploratory study

Tom WORTEL and Koen HUISSTEDE, the Netherlands

1   Introduction

1.1   Breaking down what we do and why we do it

In the process of this innovation we try not to base our ideas on empirical evidence and we apply the "first principle" thinking process. Therefore we break down the theoretical elemental building blocks of our land administration. In this research we focus specifically on the land surveying tasks.

To be able for a society to flourish it needs (among other things) public safety and a healthy economy.

- Public safety is implemented by collectively accepting rules about safety and the enforcement of those rules within the society.
- a healthy economy is implemented by (among other things) limiting the risks people have to get a return on their investment.

For both needs we should make clear to each other what belongs to whom. This is translated into a law that we register who has certain rights in the collective space and how they must be read.

In the Netherlands we implemented legal certainty through separation of powers in our governance of state. A legislature power records our rules in laws, an executive power executes those laws and a judiciary power interpret and applies those laws (also called trias politica).

The laws how to deal with the registration of rights of real estate in the collective space are recorded in the Land Registry Law (aka "Kadasterwet"). Kadaster executes this law and manages the public records of real estate transactions (aka "openbare registers") and the registry of current rights regarding real estate (aka "Basisregistratie Kadaster").

Notaries formalize a specific transaction of rights between parties in a deed which is then signed up in the public record of the Kadaster. From the transactions the Kadaster manages the current state of all rights including its boundaries in a registry (aka "BRK").

In a deed, relevant existing formal boundaries on which the transaction of rights apply are specifically referred to via ID's or similar. New, not yet formal existing boundaries are 'sketched' in a tool of the Kadaster, become a 'temporary boundary' with an ID to which it is referred to in the deed. The temporary boundaries are not specific or precise enough for the Kadaster to be able to maintain a good registry.

Therefore, to be able to register the rights correctly, the Kadaster has to ask the relevant party(or parties) that are affected by the transaction of rights in the deed to point out the exact location of the boundaries on which the rights apply.

Problems of this concept:

1. *Most parties do not understand that they have to perform an action regarding the legal situation days/weeks/months after the deed passed at the notary. This alone influences their feeling of legal certainty of their real estate (assumption, to be researched) and does not contribute to the inclusive policy (assumption: higher educated people probably have better understanding of legal constructs and understand the importance of the pointing out the boundaries better than lesser educated people).*

2. *Results of previous research by Kadaster regarding this subject shows that in case of shared ownership (for examples couples owning both 50% of the property) upfront both partners think they can represent each other but at the actual field visit the represented partner is dearly missed.*

1.2   Current implementation choices by Kadaster

At the moment we ask parties to point out the location of the boundary at the physical location. The Kadasters takes initiative in arranging a meeting on the same date with all parties. It depends on the speed of communication by the stakeholders how time-consuming this is. Sometimes it is not possible for all relevant parties (or their delegates) to meet at the same time or a party is absent at the meeting (in 50% of the cases). The Kadaster meets the parties on different times than and administers and combines all meetings in one description of the boundary. When one or more parties do show up but others related to the parcel(s) don't, they get a precise description of the boundary that is pointed out and a request to review this (15% of the cases) (aka "tervisielegging"). The party has to object within a certain time frame when they do not agree, otherwise they (implicitly) approve. (95% of the cases).

Problems of this concept:

3. *It is time-consuming for both the relevant parties and the Kadaster to arrange a meetup with all parties at the same time. A Kadaster employee visits a site by average 2.1 times before all the necessary information is acquired.*

4. *We do not know how thoroughly parties review the description ("tervisielegging"). In relation with problem nr 1 we suspect that parties implicitly approve by ignoring the request. This can be impactful for parties in the case of disputes in the future.*

5. *At the end of the whole process of legal determination of the new boundaries, parties receive a letter from Kadaster in which the new acreage is mentioned. But they don't see a map, or a sketch or a description of the boundary's they pointed out. They don't really know what we have registered.*

2 Hypothesis

All parties affected by the transaction of rights have to reach consensus on the exact location of the new boundaries and Kadaster must oversee that. The hypothesis that in a majority of the cases

> ### *this consensus can be reached using point clouds as a digital representation of the physical location.*

Resulting in
- reducing costs by Kadaster by lesser field visits and lesser work on preparing future boundary reconstruction.
- promoted inclusion by using an online portal and making it easier for parties to participate in this process of consensus.
- Making it easier for parties to understand our process and actually know what we register. They really know what they own.

2.1 Legal implications

Despite the law not excluding the new method it still is important to do research on the legal impact of changing the process.

> *Research question: Do we expect the judiciary power to react on the burden of proof in the new process? What are their (additional) requirements in the process?*

2.2 Usability implications

Not everyone is used to handling point clouds. This can be a problem for our use case, and should be one of the main focus points of the research. Point clouds mostly are used as a semi-finished product but it is the most accurate of them all. That is the main reason we want to experiment with the use of point clouds by all parties.

> *Research question: What visualizations of point clouds work best for non-professionals to be able to point out the new boundaries?*

> *Research question: What is the success rate of the usage?*

To be able to be inclusive (like stated in the effects of the hypothesis) we need all parties to feel comfortable using the digital representation. We foresee that using a digital representation is not forced upon all stakeholders at all times. Parties must feel free to choose the traditional field visit if they prefer that.

> *Research question: do people feel more or less inclusive?*

2.3   Accuracy implication

An important aspect of legal certainty is geometric accuracy of the surveys used for pointing out cadastral boundaries. This accuracy can be divided in 2 different categories.

- One is absolute accuracy, which translates to the accuracy of the resulting coordinates in a coordinate system, RD coordinates in The Netherlands. This aspect can be challenging when one decides to use point clouds with poorly described origins.
- A second aspect is the relative accuracy, describing the ability to measure accurate distances in a point cloud.

One can argue relative accuracy is more important than absolute accuracy. The idea of the border being pointed out is to capture the border with respect to the surroundings. This can be done unambiguously by drawing the border in a point cloud, the point cloud representing the surroundings and the line representing the border. The point cloud has to fulfill a number of requirements in order to be an accurate description of the surroundings:

- The cloud has to be true to size, rotations and scale in order to be able to generate repeatable, and thus reconstructable measurements.
- The cloud has to have proper point spacing in order to be able to select the right points.
- The cloud has to have proper coverage of the entire surroundings, to be able to point out all borders in one cloud.

The hypothesis in this research, which must be verified with further research, is that the Kadaster has stored enough terrestrial measurements in its databases to be able to verify the accuracy of point clouds in most areas of the Netherlands. By using these archives as control points, the cloud can be checked for deformation and scaling issues. In this way, the Kadaster can validate the suitability of a point cloud without leaving office.

Once we can conclude the relative accuracy of the point cloud can be checked using our databases with past terrestrial measurements, we can take the research a step forward and test whether we can position the point cloud in RD. In this way, the Kadaster can obtain billions of accurate absolute coordinates, which can be added to the database to be used in the future. The 3D cloud database will grow with every scan that has been tested to be suitable for pointing out boundaries, and with every scan that can be positioned in RD reliably.

> *Research question: What is the accuracy of the point clouds and their dependence on the way they are collected?*

3 Methodology

3.1 Reuse of existing point clouds

As Kadaster we want to reuse existing point clouds as much as possible. As stated earlier, point clouds are used extensively in a variety of processes and by a variety of parties. Construction companies use it for build-progress indication and as-built registration. Cities use it for as-is status on city-planning initiatives. etc.

In short, our goals are to:

- Collaborate with other organizations on the reuse of already existing point clouds
- Analyze and experience the quality of those point clouds regarding:
  - use in visualisations
  - relative measurements
  - absolute positioning

3.2 Create portal for collaboration point clouds with different parties

The basic idea is to limit the amount of field visits and use a digital collaboration space instead. We have created an online environment that can be used by anybody with a browser and internet. The environment is user-based so all parties can login with an account (in the research state this is a simple login).

The determination of a single boundary is project-based. All relevant information including the point cloud is loaded into one project environment. Relevant parties for this boundary are invited join the project environment. A specific stakeholder only sees the projects that are applicable to him/her.

Everybody in the project-space shares all data. Everybody can draw lines that represent borders, add notes to that lines, move the lines. The portal keeps track of all changes made in the project space.

After collaborating (which can take several iterations because not everybody is present in the portal at the same moment) all parties give their explicit approval of the given information in the project. The Kadaster is always present as an independent source of surveying advice. The land-surveyor has more construction tools at his disposal in the online environment to be able to assist the owners in determining the boundaries.

3.3 Experiment with real stakeholders

To get proof on how the portal and the point cloud is experienced by stakeholders we have to experiment with real stakeholders.

- We start experimenting with organizations that own many parcels. We already have contact persons and those organizations are keen on participating in this research.
- We will experiment on parcels that have already been measured in the traditional process
- We will experiment with the same stakeholders
- Observe differences in the way stakeholders experience the process (new vs current)
- Observe differences in the resulting boundary accuracy, relative as well as absolute

3.4 Future expand to usage in other countries

As the Dutch Kadaster we have 185+ years of experience in land administration. Still, a lot of countries do not have a proper land administration. Kadaster International helps those

countries with a fit for purpose approach. Different forms of the hypothesis in this paper are also relevant for those countries. Kadaster International already has experience using other types of data for determining the parcel boundaries. We keep close contact and will collaborate when useful/needed.

4   Conclusion

4.1   Legal implications

In the current Kadasterwet it is <u>optional</u> to visit the physical location to point out new boundaries by stakeholders of the deed. So the Kadaster can use other ways of gathering the necessary information.

The current Kadasterwet states that all parties have the right to receive "surveying advice" by Kadaster. So Kadaster must oversee the process of consensus on pointing out the new boundaries and give parties asked and unasked (independent) advice.

In a small number of applications (2%) the Kadaster uses other sources than a field visit to obtain the information to determine the boundary. In these cases all the relevant parties make a statement that they will not point out the boundaries in the field and are asked to deliver digital measurement data of the boundaries which Kadaster can use to shape the new parcel (aka "meetgegevens van derden"). Examples are fields that cannot be visited easily (highways, railroads, etc). Because this is used in only a few cases, there is not much jurisprudence (case laws) of disputes on boundaries determined in this way.

4.2   Usability implications

We have already seen that the density of the points has to have a minimal height for people to recognize the site and her objects. Also coloring the points based on photographs helps drastically in good usability.

More results of actual usability are yet to be gathered based on the experiments with actual stakeholders in the upcoming months.

4.3   Accuracy implications

Lots of research has been performed on the accuracy of point clouds. We are aware that the accuracy of point clouds is highly dependent on the setup of the measurements. In general, a number of widely known measurement setups lead to point clouds that are accurate enough for our purposes:

1. Static laser/lidar scanning with targets on control points, surveyed with levelling and total stations
2. Ditto, surveyed with GPS (approach used by Geonext)
3. Dynamic laser /lidar scanning (from a moving vehicle or aerial platform or handheld device)
   a. using ground control points
   b. using GPS-RTK or PPK / IMU. (Inertial Measurement Unit)
4. Photogrammetrically obtained point clouds, terrestrial or aerial. Using dense matching.
   a. Using ground control points (with targets)
   b. Using GPS-RTK or PPK / IMU.

What we are trying to achieve, is using point clouds without controlling the way the measurements are performed, and still obtain sufficiently accurate measurements for our purpose. We try to do so using large scale adjustment based on existing coordinates and

measurements in our databases. Future research should be performed to validate this approach.

REFERENCES

https://www.un-ihe.org/sites/default/files/2017_unesco-ihe_phd_thesis_meesuk_i.pdf

*Kadasterwet (*https://wetten.overheid.nl/BWBR0004541/2020-01-01*)*

T.C.F. Sassen, The influence of drone flightpath on photogrammetric model quality, 2019

B. Sirmacek, R. Lindenbergh, ACCURACY ASSESSMENT OF BUILDING POINT CLOUDS AUTOMATICALLY GENERATED FROM IPHONE IMAGES, 2014

Meesuk, Vojinovic, Mynett; MERGING TOP-VIEW LIDAR DATA WITH STREET-VIEW SFM DATA TO ENHANCE URBAN FLOOD SIMULATION, 2011.

Zlatanova, S., Oosterom, P., Verbree, E., 2004. 3D TECHNOLOGY FOR IMPROVING DISASTER MANAGEMENT: GEO-DBMS AND POSITIONING. Proceedings of The IEEE - PIEEE.

Tschirschwitz, F., Kersten, T.P., Zobel, K., 2014. Interactive 3D Visualisation of Architectural Models and Point Clouds Using Low-Cost-Systems, in: Ioannides, M., Magnenat-Thalmann, N., Fink, E., Žarnić, R., Yen, A.-Y., Quak, E. (Eds.), Digital Heritage. Progress in Cultural Heritage: Documentation, Preservation, and Protection, Lecture Notes in Computer Science. Springer International Publishing, pp. 268–278.

http://www.cs.cornell.edu/projects/bigsfm/

https://fs.blog/2018/04/first-principles/

BIOGRAPHICAL NOTES
Koen Huisstede is enterprise architect and member of the emerging technology centre.
Tom Wortel is advisor tactical information management in the geodetic aspects of the cadastral registry
Both authors are employed by Kadaster.

CONTACTS

Koen Huisstede
Kadaster
Hofstraat 110

7311 KZ Apeldoorn
THE NETHERLANDS
Tel. +31 6 5248 1535
Email: koen.huisstede@kadaster.nl
Web site: http://www.kadaster.nl

Tom Wortel
Kadaster
Hofstraat 110
7311 KZ Apeldoorn
THE NETHERLANDS
Tel. +31 6 5016 0479
Email: tom.wortel@kadaster.nl
Web site: http://www.kadaster.nl