Evaluation of the Additive Manufacturability of CAD-Parts for initial Data Labelling in AI-based Part Identification

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Abstract. The objective of this study is to develop and implement an analysis tool that identifies CAD geometries which impair Additive Manufacturing. A key performance indicator is generated to be used as data label representing the manufacturability for a future application of AI. Relevant geometric features are identified and algorithms to evaluate critical features are developed. The analyses include part orientation, build volume, wall thicknesses, gap widths, bore and cylinder diameters as well as the process-specific factors powder removal and need for support structures. The manufacturability of a part is calculated as Additive Manufacturing Feasibility Indicator (AMFI), depending on the identified critical features and a user-specific weighting. The AMFI successfully serves as data label which is suitable for application in AI methods. The developed GUI supports designers by highlighting critical features directly in the CAD environment and allowing the user in a purposeful part optimization for AM.

1. Introduction and Motivation
Additive Manufacturing (AM) processes are increasingly moving into the focus of product development nowadays. The potential application of AM processes can be found where products are to be manufactured with great freedom of design, individualised for customers or in a decentralised production to ensure independence from external supply chains. Conventional manufacturing processes often reach their limits regarding these factors. However, a high level of expertise regarding process parameters and design guidelines are required to manufacture parts using AM. Companies often lack the necessary expertise and methods to identify potential parts for AM, which is an obstacle to the successful introduction of AM processes. Overcoming these hurdles with the support of artificial intelligence (AI) methods is a promising approach. Generative design software already uses machine learning technology to propose solutions to a design problem that meet the technical requirements [1]. However, there is no assistance provided yet that offers a basic assessment regarding the manufacturability of a part using AM. An automated manufacturability assessment for AM could support the integration of AM processes into existing production landscapes to improve the value of technical products and provide an economic benefit for companies.

2. State of the Art
In the following, the state of the art regarding part identification for AM by AI methods as well as relevant parameters in AM will be discussed to disclose the need for research in this topic.
2.1. Artificial Intelligence in Part Identification for AM
A first study has shown that parts with high potential for AM can be automatically identified in a CAD database using AI algorithms that evaluate the geometric complexity of a part [2]. In this supervised learning approach, the relationship between given CAD-files as input data and pre-assigned output values is learned by an Artificial Neural Network (ANN) as AI algorithm. The derived classifier is suitable for assigning parts to the clusters "AM potential" and "no AM potential" with an accuracy of over 90%. The procedure and used toolchain are presented in figure 1.

In order to train the AI algorithms for the part identification, a sufficient amount of data with known input and output information (labels) is required to obtain an optimal AI-model. The minimum amount of training data depends on the type and structure of the AI algorithm used, as well as on the quality of the training data. The use of a training data set of about 1500 parts as in the study mentioned above can already lead to valid results avoiding that the influencing variables do not describe the target variable sufficiently well (underfitting). In principle, the quality of the network increases with the number of different training records [3].

Literature research reveals that there are currently no methods or tools known to perform an automated labelling of CAD-data with regard to their manufacturability by AM. A manual labelling of all parts in the dataset as performed in the abovementioned study requires expertise in the field of AM and is not expedient with a required time of 1-2 minutes per manual label assignment.

2.2. Characteristic Indicators for AM
Geometric part complexity, as used in the above-mentioned study, can successfully be used as an indicator for AM potential. The literature research on additional characteristic indicators in Design for AM (DfAM) guidelines, reveals that the indicators can roughly be divided into two categories [4]. On the one hand, there are indicators that deal with the potentials of AM processes [5, 6], on the other hand there are indicators that deal with restrictions [7, 8, 9, 10]. Table 1 gives an overview of the most relevant characteristic indicators for AM and divides them in the two categories opportunistic and restrictive.

| Characteristic indicators | Opportunistic indicators | Restrictive indicators |
|---------------------------|--------------------------|------------------------|
| Part complexity           | Suitable of material     |
| Degree of customizability | Batch size of the part    |
| Functional integration    | Required design quality   |
| and part consolidation    | of the part               |

Table 1. Overview of Characteristic Indicators for AM [4]
As a third category, some authors add the "combined" or "dual" DfAM approaches, which represent a combination of the two previous categories but will not be further considered in this study because they are considered subordinate. In some cases, the assessment of manufacturability is considered as separated indicator alongside of the restrictive indicator design quality, what further underlines the necessity of an assessment of the manufacturability of a part [4].

2.3. Manufacturability as restrictive indicator
Primarily, the limitations of a manufacturing process are crucial for successful additive manufacturing when considering the manufacturability as a restrictive indicator. A large number of different limitations and guidelines can be found in the literature, both with regard to the physical shape of the components and their quality.

Since the design quality of an additive manufactured product is always based on the design quality of the individual geometric elements of which it is composed, special features are often examined in literature for their manufacturability [5, 7, 8, 11, 12, 13]. The characteristic values mentioned apply equally to most of the relevant AM process. In addition to these generalisable factors (e.g. see table 2), process-specific limitations for the most industrially relevant powder-based and material extrusion processes have been researched in the literature [7, 11, 14]. Representatives of powder-based processes include the Selective Laser Melting (SLM), also known as Laser Powder Bed Fusion (LPBF), and Selective Laser Sintering (SLS). In the field of material extrusion, the Fused Filament Fabrication (FFF), often called Fused Layer Modelling (FLM), should be mentioned [15]. Table 2 presents a summary of the most important general and process-specific factors regarding the additive manufacturability of parts focusing on powder-based and material extrusion processes.

Table 2. Overview of the most important factors regarding the manufacturability of AM parts

| General factors | Process-specific factors |
|-----------------|-------------------------|
| Minimum wall thickness | Powder-based processes |
| Minimum gap width | Critical hole diameter |
| Minimum bore diameter | Cavities |
| Minimum cylinder diameter | Material extrusion processes |
| Part orientation | Min. cross-sectional area |
| Build volume | Critical overhangs |
|                  | Islands |

At this point it should be noted that the mentioned factors do not cover all existing process limits due to the complexity and variety of additive manufacturing processes. However, these factors represent the central general and process-specific factors that limit the most common AM processes. That is proven on the one hand by their frequent mention in the literature and on the other hand by the degree of their research. However, there is currently no known solution that automatically analyses these factors and makes an assessment in terms of additive manufacturability.

2.4. Automation in the AM Process Chain
The Mechanical Engineering Industry Association (VDMA), Europe's largest industrial association, founded the working group Additive Manufacturing (AG AM) already in 2014 [16]. The ambition of the AG AM is to increasingly integrate AM processes into industrial process chains. A detailed documentation of the entire process chain of AM has been prepared by the AG AM in order to capture the current state of development of the individual process steps on the path from manufactory to Smart Factory. This has resulted in the roadmap "Automation for Additive Manufacturing" (see figure 2), in which an extensive amount of know-how for the integration of AM technology in industrial production processes is compiled and potentials for future development towards automation are listed [17, 18].
Figure 2. Roadmap “Automation for Additive Manufacturing” adapted from [18]

The necessary pre-processing steps regarding the digital part preparation are marked in the figure above. Prior to the manufacturing process, the CAD data from the design domain have to be prepared for the application in the layered manufacturing process. Information on component geometry, tolerances and functions are incorporated into the production data. These data are adapted according to the desired manufacturing process. In the subsequent digital production preparation process, this data is imported to arrange the parts in the build space, if necessary define support structures and simulate the build process.

When examining the individual process steps in this digital area of the manufacturing process chain, many of today's processes require manual inspection by a manufacturing employee. If deficits in the part design are found which impair production, the component design has to be adapted by the design domain and a new inspection needs to be carried out which is a time-consuming iteration. The simulation and optimization of the build process is carried out in a similar manual process. Current work in progress primarily focuses on a software-supported screening of part defects as errors in the mesh structure. However, tools are only available as individual solutions or at a demonstrator stage. To reach a full automation in the digital data preparation the desired future solution is described as an assistance system implemented in CAD software. It should include intelligent algorithms for automated data creation and manipulation, that consider economic efficiency, high quality and process safety already during the design phase of a part [17, 18]. The consideration of the additive manufacturability of a part in early design process stages is also identified as a goal by consultants and service providers in order to close the existing gaps in a broad industrial application of AM [19, 20].

3. Need for Research
The preceding remarks on the state of the art reveal the need for research in the field of an automated manufacturability assessment of parts for AM. To reach the goal of economic efficiency, there is a need to support the design domain regarding design for AM by early assessment of the manufacturability to reduce cost for design iterations and time to production. The application of AI for part identification for AM also needs be further researched to exploit its promising potential. The following research questions and hypothesis are derived to address the white spot in the research area.

Research Questions
How can the effort for data labelling of parts with potential for additive manufacturing be decreased by an assessment of the manufacturability?

- Which geometric elements of a part does the feasibility of additive manufacturing depend on?
- How can these geometric elements be evaluated automatically with regard to their additive manufacturability?
- How can the result of the AM feasibility analysis serve as a data label for an application of AI methods?
Research Hypothesis
Based on the part geometry depicted in CAD the manufacturability of the parts in specific AM processes can be evaluated to derive a suitable characteristic value as data label.

Objectives of the Study
The intention of this study is to leverage applications of AI and AM in product development. The overall objective is to develop and implement an analysis tool that evaluates restrictive part geometries in CAD files that impair AM and that generates a key figure that can be used as data label representing the manufacturability. Based on this overall objective, the following sub-objectives were defined for this study:

1. The most relevant geometric features that might impair AM are identified and graded
2. Methods to evaluate these features are developed and implemented in CAD software
3. The manufacturability is determined by a calculation method based on feature evaluations

4. Methodical Approach and Materials
The methodical approach for the assessment of manufacturability in AM first of all intends to determine the relevant restrictive factors that disqualify parts for manufacturing using AM. This step is followed by the evaluation of these factors in a general and process-specific analysis using algorithms in the CAD software. Finally, a key figure representing the manufacturability is calculated. The used methods for each step are described briefly in the following chapters.

Further, the given constraints for the research and development have to be determined to achieve the objectives of the study. The concepts and solutions developed within the framework of this study target the integration into the AI part identification toolchain for AM presented in the state of the art. Since the part analysis and the derivation of characteristic values in the AM toolchain is carried out in the CAD software Siemens NX, the NXopen interface is also intended for this study. NXopen offers a programming interface to access the part data, perform analyses and calculate characteristic values. To further process the calculated values in the AI toolchain, data transfer via an Excel sheet is used.

Regarding the process-specific analysis three AM processes are focused to cover a wide range of industrial relevant applications. The SLM process is considered as a representative of powder-based processes using metals. At the other end of the relevant range the FLM as a material extrusion process using polymers is acknowledged. The third process between the abovementioned is the SLS process. These AM processes are sufficiently widespread in industrial practice and guidelines for the design of components, as well as the potentials and restrictions of the respective processes are well researched in order to derive generally valid methods.

To allow the usage of the calculated key figure as data label, a normalised value between 0 and 1 is required. In this study, the value 0 represents that the part is "not feasible in AM" and 1 stands for "feasible in AM". Values between the two extrema indicate that a component is partially suitable for AM and some geometric areas may need to be redesigned.

The ABC dataset containing more than one million CAD files is used as dataset for validation. Its applicability regarding AI has already been proven in former studies [2, 21].

4.1. Relevant restrictive features for this study
As mentioned in table 2 there are several factors, which are important, when it comes to the manufacturability of AM parts. Almost all of the mentioned factors can be directly translated to restrictive and thus critical features for the additive manufacturability of a given part. The only two exceptions are the part orientation as well as the given build volume.

Although both factors in combination can easily lead to an exceedance of the given build volume of the printer and can thus be declared as critical, they do not represent a feature of the given part. Furthermore, the part orientation has an influence on the restrictive features, as their orientation in the layer wise build processes of AM influences their manufacturability. In order to distinguish manufacturability in the printing direction (Z-axis) and the printing plane (X-Y plane), the orientation
of the component must first be defined. After the definition of the part orientation all other features can be directly derived by means of geometrical and mathematical analyses within the CAD software.

4.2. General Analysis

As mentioned earlier general restrictive features can be analysed equally across all relevant AM processes. Although not characterized as a critical feature of a given part, the first step in the analysis has to be the definition of the part orientation within the given build volume. Afterwards the analysis of the focused general restrictive features like the minimum wall thickness and gap width as well as the minimum bore and cylinder diameters will be discussed.

4.2.1. Part Orientation and Build Volume

In order to analyse all following restrictive features, the part orientation has to be determined first. There are several possible optimisation strategies regarding part orientation that pursue different goals. For example, parts can be oriented according to functional requirements such as surface quality and tolerances. If functional requirements are demanded for special surfaces, parts usually need to be post-processed. Therefore, this study follows an optimization strategy focusing on process reliability regarding FLM processes and thus identifies the orientation for the best adherence of the part on the print plate.

To achieve this, an algorithm was created, which first identifies all plane faces of the given part and checks if these are possible print bases by verifying if the planes are outer boundaries of the part. Afterwards all identified bases are analysed and coplanar faces are cumulated. Beginning from the largest base area, the part is then oriented using the normal vector of the face and the minimum bounding box of the part is derived. This bounding box is then compared with the given build volume of the printer and the largest possible base area is chosen as the basis for the orientation of the part. If no possible base can be identified or all bases result in an exceedance of the build volume, the minimum bounding box resulting from the orientation in the native z-direction of the part is checked. If this step does not result in a possible orientation it is declared, that the given part cannot be manufactured regarding the given orientation strategy. It is conceivable to integrate other orientation strategies in the procedure or to let the user specify an orientation.

4.2.2. Minimum Wall Thickness and Gap Widths

After aligning the part according to the identified orientation, the part is checked for deviations of minimum wall thicknesses and gap widths. In order to perform this analysis an algorithm is designed that slices the part in several equidistant planes parallel to the print base. From the resulting slices, the boundary curves are extracted and analysed via a comparison of pairs. In these comparisons it is checked whether the paired curves are the same curve, neighbouring curves or other curves. Afterwards the type of curve is checked. Depending on these two parameters the type of analytical comparison varies from a mere analysis of the contact angle of the curves (figure 3 a) through the analysis of the distance between the beginning and end point of the curve (figure 3 b) to the analysis of the distance between sets of equidistant points on the curves (figure 3 c).

![Figure 3. Exemplary results when checking wall thicknesses and gap widths](image)

Shortfalls of the minimum wall thickness and or gap widths are recorded and the critical curves are determined. Afterwards the faces, which are related to the critical curves are derived and it is checked whether the faces achieve the minimum wall thickness or gap width.
An equivalent analysis is performed for the minimum wall thicknesses and gap width perpendicular to the print direction, although in this direction only the wall thicknesses and gap widths parallel to the print direction are considered.

### 4.2.3. Minimum Bore and Cylinder Diameters

Similar to the minimal wall thickness and gap width the minimum bore and cylinder diameter can also be checked in print direction and perpendicular to this direction. To find holes and cylinders which fail to achieve the minimum diameter, first all cylindrical faces of the part are identified. Afterwards it is determined if the face belongs to a bore hole or a cylinder and the direction of the central axis is identified.

With this direction and the print orientation the minimum radius of the section ellipsis is determined for the print direction as well as perpendicular to the print direction (see figure 4). If this radius falls short of the minimum bore or cylinder radius, the bore hole respectively cylinder is characterized as critical.

![Figure 4. Section of an angled hole parallel to the building plane and creation of a sectional ellipse](image)

### 4.3. Process-specific Analyses

As the name suggests, process-specific factors depend on the selected AM process. The focused AM processes are powder-based processes (SLS and SLM) and material extrusion processes (FLM) which both have different restrictive features. Whereas for powder-based processes it is important to ensure the removal of the powder from holes and cavities, material extrusion processes tend to overheat features with small cross-sectional areas and need support structures in order to print features with critical overhangs and islands.

#### 4.3.1. Powder Based Processes

In order to ensure the powder removal from bore holes, the literature suggests to stay below a certain length to diameter ratio $R_{LD}$. To assess this ratio all cylindrical faces, which form holes are extracted from the CAD model. Afterwards their lengths $l_H$ and diameters $d_H$ are extracted. With both values $R_{LD}$ can be calculated and critical holes identified.

$$R_{LD} = \frac{l_H}{d_H} \quad (1)$$

Another important feature to consider, when talking about the removal of access powder are closed cavities. For cavities there is no specific limit value that can be derived from literature. Therefore, it is decisive to detect the occurrence of closed cavities in the given CAD model. To do so a cuboid with the measurements of an enlarged bounding box of the part is created and the model itself is subtracted from the cuboid. If the result of this operation creates $n$ bodies with $n$ larger than one, the part has a total of $n - 1$ closed cavities. If the resulting number of bodies is equal to one, there are no closed cavities in the model.

#### 4.3.2. Material Extrusion

To determine whether features of the CAD model are prone to overheating during the manufacturing process, the minimum cross-sectional area was introduced. To determine the parts of the CAD model which fall short in regard to this area, the part is sliced in several equidistant heights parallel to the print
base. At every height the section faces are extracted and their area is measured. If a shortfall is detected, the associated feature of the section area is determined.

In order to minimize the usage of support structures and thus the need for postprocessing, the areas of the CAD model, which need such structures may also be detected by the algorithm. A critical value to identify the areas in need for support structures is the critical downskin angle of the faces. For regular faces like planes, cylinders and cones the determination can be achieved via the normal vector of the planes or the central axis of the cylinders and cones in combination with the cone angle respectively (figure 5 a). For free-form surfaces or other more complex faces, a net of test points is projected onto the face and the normal vector of the face at these points is extracted. With this vector the downskin angle can be calculated and compared to the minimum downskin angle.

Other areas of the CAD part in need for support structures are islands. In order to detect such structures, the part is repeatedly sliced in several equidistant heights and the resulting section areas are extracted. Afterwards the number of areas is compared to the one in the previous section. If the number increases, potential islands are detected. To check whether the detected areas are actually part of an island, an equidistant net of test points is projected onto the areas of the previous slice and from there projected onto the next layer. The areas, which are free of any test points are then declared as part of an island and the related geometric features of the CAD part are extracted (figure 5 b).

4.4. Evaluation of manufacturability

To finally provide a measurable key figure representing the manufacturability of a component in a specific AM process the Additive Manufacturing Feasibility Indicator (AMFI) is developed. This measure allows to derive a statement regarding the manufacturability on the basis of the critical features described before.

Due to the current diversity of additive production plants and the different process capabilities, the effect of recognized critical features should be adjustable by user-specific weighting. For this purpose, the user is given the possibility to specify a maximum allowed number $q_{max,k}$ for each type of critical features identified, which may occur within a component. In addition, the user should be able to specify a value for each of these features for its integration $i_k$ into the evaluation of manufacturability. This selection is made possible for both general and process-specific factors. Since the surfaces that require support structures do not directly influence the manufacturability of a component, they are not included in the evaluation at this point.

In order to specify a single key figure representing the manufacturability, the first step is to calculate the manufacturability of the individual critical features. For this purpose, it is checked whether the number of detected instances $q_k$ of a critical feature exceeds the maximum number specified by the user.
If this is the case, then the manufacturability $m_k$ of this feature is set to zero. If this is not the case, then the manufacturability of this feature is calculated as follows.

$$m_k = 1 - \frac{q_k}{q_{max,k} + 1} \quad (2)$$

Once the calculation of the manufacturability of the individual critical features has been completed, they still have to be combined to the total manufacturability. For this purpose, the weightings $w_k$ provided by the users are calculated for the individual features using the following calculation rule.

$$w_k = \frac{t_k}{\sum_{j=1}^{n} t_j} \quad (3)$$

The AMFI of a part $P1$ can now be calculated as the sum of the products of the manufacturability of a feature $m_j$ and the user-specific weighting $w_j$.

$$AMFI_{P1} = \sum_{j=1}^{n} m_j \times w_j \quad (4)$$

The overall approach of the quantification of manufacturability in form of the AMFI and the applied tools are illustrated in the following figure 6.

**Figure 6.** Process of the manufacturability analysis to calculate the AMFI

5. Results

The objective of this study was to develop and implement an analysis tool that evaluates restrictive part geometries in CAD files that impair AM and that generates a key figure that can be used as data label representing the manufacturability. The foundation of this analysis is given by the identification and evaluation of the most relevant geometric features that might impair a successful AM build. The developed algorithms described above evaluate the general factors build volume, wall thickness and gap widths as well as bore and cylinder diameters. Depending on the chosen AM process, process-specific parameters are analysed afterwards. For powder-based processes, channels and cavities in the part are specifically analysed to ensure successful powder removal. The cross-sectional area, overhang angles and islands are relevant factors in material extrusion and therefore analysed. Depending on the number of critical features identified in the analyses and their user-specific weighting, the AMFI of a part is calculated. The AMFI is designed to take values between 0 and 1 to meet the requirement for a suitable data label in the AI tool.
Therefore, it is proven that suitable characteristic values for data labelling can be derived from the part geometry depicted in CAD and that the manufacturability of the part geometry can be evaluated for specific AM processes. Further, the time for the automatic part analysis at approx. 30-40 seconds is significantly less than a manual analysis.

For the integration of the analyses in Siemens NX a graphical user interface (GUI) has been developed in order to control the part analyses in a user-friendly way and to query necessary user-specific process limits. The GUI guides the user through a five-step process and allows the display of the results. Figure 7 illustrates the process steps that can be carried out for the analysis of a part. Step (a) allows the user to select one of the three mentioned AM processes to be used for part production. Afterwards, process limits can be adjusted individually for the general and process-specific analyses in step (b) depending on the focused AM plant. If the user does not wish to include individual factors in the calculation, this can be set in step (c) via the percentage weighting of the factors. Further, the maximum number of critical instances of a specific feature can be specified. If more than the specified critical instances are detected in a part, the feature is indicated as not manufacturable (value 0). The analyses are carried out in the CAD software and an overview of recent analyses and the examined parts including their AMFI is prepared for the following step (d). The user is now able to choose one of the examined parts and in step (e) a table of the instances of each identified critical feature is presented for a user selection. Finally, the selected critical feature can be displayed directly in Siemens NX.

(a) Basic settings (b) Settings of process limits (c) Settings of weightings (d) Analyses and AMFI (e) Selection of critical features

Figure 7: Developed user interface for setup and evaluation of the AMFI in Siemens NX

To illustrate the usage of the AMFI tool figure 8 presents the analysis of an exemplary part. The calculated AMFI of this part results a value of 0.6. All weightings of the critical factors were rated equally for the calculation and each critical feature may be present a maximum of once. The evaluation reveals that the part contains areas that might be critical for AM as small bore diameters (a), cavities (b) and islands (c). No critical wall thicknesses, gap widths or cylinder diameters are detected. Therefore, the AMFI is calculated as shown in equation (5).

\[
AMFI_{\text{example}} = \frac{1}{5} \times \left( \left(1 - \frac{0}{1+1}\right) + \left(1 - \frac{0}{1+1}\right) + \left(1 - \frac{2}{1+1}\right) + \left(1 - \frac{0}{1+1}\right) + \left(1 - \frac{2}{1+1}\right) \right) = 0.6
\] (5)

The AMFI value of 0.6 can be interpreted in such a way that the part is not fully proven to be successfully manufactured according to the specified process limits. Because of the identified critical features, it is advisable to check the highlighted areas (see figure 8) and rework the design.

(a) Basic settings (b) Settings of process limits (c) Settings of weightings (d) Analyses and AMFI (e) Selection of critical features

Figure 8: Indication of critical features in CAD
Validation
Finally, the presented method is validated with regard to its applicability for the automated data labelling of large CAD data sets. A subset of the ABC dataset of 3000 CAD-Files is analysed by the developed method and the calculated values for the AMFI are stored as data label. As an example, the process parameters and limits of the Prusa i3 MK3S printer were used as reference [22]. The diagram in figure 9 presents the distribution of the analysis results for the AMFI by plotting the number of parts on the logarithmic Y-axis over the AMFI values on the X-axis.

1280 parts are labelled with a value of 1, which means that they hold no geometric restrictions for AM. A sample inspection of these parts proves that all are suitable for AM. 1085 of the analysed parts are assigned with an AMFI value greater than 0 and less than 1. Critical geometric elements for manufacturing are identified in these parts. A total of 431 parts are assigned the AMFI value 0 because the dimensions of their bounding box exceeded the Prusa printers build space limitation of 250 x 210 x 210 mm (X x Y x Z).

![Figure 9. Results of the AMFI calculation of the validation data set](image)

The AMFI calculation failed for the remaining 204 parts not indicated in figure 9. The analysis of the error rate of 6.8 % reveals that the analysed parts mostly show inconsistencies in the modelling, such as several intersecting bodies in one file (a) or consist of a high number of free-form surfaces with complex numerical definition (b) as shown exemplarily in figure 10. The presented analysis algorithms need to be further improved to intercept these kinds of errors and also provide an analysis of complex free-form surfaces.

![Figure 10. Examples of failed part analyses](image)

6. Summary and Outlook
The developed toolchain realizes an automated evaluation of a large number of CAD data regarding their additive manufacturability. The presented indicator AMFI can be determined to quantify the manufacturability of a part using AM and thus make it accessible for further applications of data analysis. The challenge of a time-consuming manual data labelling described in the state of the art can be automated following this procedure. This allows an analysis of the necessary large amount of training data for AI applications and an unbiased labelling in a shorter period of time. In order to optimize the method, the analysis algorithms need to be further improved in order to be able to better evaluate components containing free-form surfaces. Since the AMFI is calculated in a value range between 0 and 1, it is suitable to serve as label for the training of AI algorithms like ANN. The application of the AMFI in combination with the existing AI toolchain will be conducted subsequently to this study.
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