Tool name	Reference	Description	Regarding curvature computation if any	Language	Comments (e.g. strengths (+), weaknesses (-))
AutoRoot	[23] Pound et al., 2017	* system designed to analyse plant images in an automated manner * no thresholding approach; instead calculates a 'likelihood' that any given pixel belongs to the root system * Dijkstra's shortest path search through all pixels (similar to *RootNav*): graph with a node at each pixel, and edges between neighbouring pixels * weights in this system are based solely on the grayscale intensity of the pixels	Not known	C#	To be evaluated
RootNav	[22] Pound et al., 2013	* top-down approach: no adaptive thresholding, fits a root model to the image data * probability-based: calculates likelihood that given pixel corresponds to root using Expectation-Maximation classification algorithm * combined pixels are clustered into groups based on their intensities by fitting a Gaussian mixture model	Not known	C# using the .NET framework libraries	+ allows user to guide the model fitting process

Tool name	Reference	Description	Regarding curvature computation if any	Language	Comments (e.g. strengths (+), weaknesses (-))
GiA Roots (General Image Analysis of Roots)	[60] Galkovskyi et al., 2012	* fully automated pipeline that extracts dozens of root system phenotypes * specifically designed for high-throughput analysis * includes user-assisted algorithms to distinguish root from background * user can select from 3 different thresholding approaches to identify roots from noisy images	Not known	C++	+ fully automated workflow + can be executed from GUI or command line + extensible - high user interaction, but not enough if image quality varies significantly from image to image - API is currently only available for libraries written in C++
EZ-RHIZO	[25] Armengaud et al., 2009	* integrated software for the fast and accurate measurement of root system architecture * semi-automated * operates on the principle of skeletonisation	Not known	C++ using Microsoft Visual Studio 2005	+ good at dealing with low contrast (allows the user to adjust the threshold for 'black and white' conversion) - plants need to grow on a solid support medium
DART (Data Analysis of Root Tracings)	[55] Le Bot et al., 2009	* allows measurements as root length, curvature and/ or architectural properties across time-series * gives supplementary, i.e. topological, meaning to the information extracted from the measurements of root images	Not known	Java	+ user draws the skeleton of the root system using freehand graphical tools - relies on manual procedures to minimise the risks of errors and biases in datasets

Tool name	Reference	Description	Regarding curvature computation if any	Language	Comments (e.g. strengths (+), weaknesses (-))
RootTrace	[5,47] French et al., 2009 and 2011	* can automatically measure multiple growth parameters on multiple roots throughout large times series * can recover changes in the curvature of the root * can determine when the gravitropic response occurred * uses particle filter-based tracking methods to trace from a user-defined start point to the root tip * estimate of growth direction in the tracking model predicts the root location at each step forward * an appearance model is then used to evaluate hypothesis of location Extensions (2011): * gravity independent tracking * capture lateral roots	* uses local angles at each point along the root trace, by taking neighbouring points of a fixed distance from the current point in the trace and calculating the angle (between the two lines formed by joining each of the points with the current point) * defines the point of the bending as the point along the root that forms a triangle with the maximal area when joined to the start point and end point of the trace	C++ using Microsoft Visual Studio 2005, OpenCV	+ flexible + extensible + user interaction is kept to a minimum, e.g. only required on first frame + gives an easy-to-interpret output + using images taken by standard digital cameras, without any special lighting - designed to work with images of roots grown on agarose plates - cannot trace root in any direction but only in the direction of gravitropic response (added in 2011) - root could not be tracked if root tip bent > 90 degrees (added in 2011)

Tool name	Reference	Description	Regarding curvature computation if any	Language	Comments (e.g. strengths (+), weaknesses (-))
KineRoot	[36] Basu et al., 2007	* allows measurements as root length, curvature and/ or architectural properties * monitors curvature of roots and gives an output relating to the degree of bending of the root * requires the user to initially define sufficiently large number of points per root * requires a sufficiently textured root surface to allow reliable tracking of control patches	uses edge detection algorithm that provides root midline, from which root curvature is calculated via formula	Matlab 7.0	+ ability to detect root edges + ability to measure curvature and elongation rates along the root - requires the user to initially define sufficiently large number of points per root - requires a sufficiently textured root surface to allow reliable tracking of control patches - images employed were microscope scale, reducing the number of roots that can be analysed at each time step - unmagnified images used were of physically larger roots than Arabidopsis, allowing more detail to be visible

Tool name	Reference	Description	Regarding curvature computation if any	Language	Comments (e.g. strengths (+), weaknesses (-))
SmartRoot	[35,36,37] Draye et al., 2007, 2011, 2013	* analyses root architecture from scanned images of plant roots * based on root tracing	uses adaptive distances between nodes in order to maintain the accuracy of the segmented representation of the roots while minimising the number of nodes	ImageJ, relies on Java, SQL and XML	+ provides a powerful vector representation of the root architecture, allowing comparison across plants and time points - designed with a large amount of interaction from the user in mind - not suited to high-throughput analysis
RootLM	[48] Qi et al., 2006	* can measure the lengths of segments of Arabidopsis roots * e.g. allows to determine per-day growth rates	* determines each root segment using the connected component method * number of pixels along the root segment is divided by the cosine angle between the straight line connecting the two end points of the root segment and a vertical line	Matlab 7.0.1	- requires the user to manually mark up the plate on which the roots sit with different coloured marker pens to indicate the growth during different growth phases - after plates are scanned in, images are manually touched up in photo-processing software - hardly scalable approach

Tool name	Reference	Description	Regarding curvature computation if any	Language	Comments (e.g. strengths (+), weaknesses (-))
Measuring Relative elemental growth (REGR) analysis	[8] Chavarría Krauser et al., 2008	* allows measurements as root length, curvature and/ or architectural properties * uses the structure tensor method to construct a velocity field * the position of a point can be tracked in time; this was used to track the control points of a curve * can compute the growth velocity from the change in distance between the control points	curvature was determined as being the angle formed by the tip and the horizontal, measured using cross-correlation to fit a region of interest (the root tip) to a reference image and thus determine the new orientation	C++	- used on microscope images of single roots captured using transmitted near-infrared light